Original Article: Comprehensive Review of the Effect of Reactor Input Temperature Changes and Unit Capacity on Gasoline Octane Number

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ABSTRACT

As mentioned above, the most important factors and parameters affecting the gasoline product octane number are the input temperature of the reactors and the capacity of the catalytic converter unit. Therefore, considering the importance of these factors and their widespread use in different operating conditions of the operating unit, the study and preparation of information and complete and comprehensive results in this regard for the use of staff at the time of occurrence of each various operating condition seems necessary and essential. This study was carried out in a fixed mass of 200 gr/hr with a purity of 90% and a stabilization of 3.5% of the coke formed on the catalyst. The main difference between this experiment and the preceding ones is the number and method of introducing and using the variables and their display.

Introduction

In In previous modes, an independent variable was always determined and used, while in this study, two independent variables were used to observe the variations of a dependent variable. Thus, the results chart of this study is obtained in several pages in space [1-5]. In this experiment, the capacity of a catalytic conversion unit based on the mass flow rate of the heavy naphtha refined feedstock, and the reactor input temperature is determined as an independent variable, and the octane number is a dependent variable [6-9]. The total points or stages obtained in this study are 493 points calculated. This chart is available through the software of Petrochem, the ability to move and rotate for access, and the ability to view the results more accurately [10-15].

As can be seen from the results, the optimum input temperature of the reactors is 525 °C, because in addition to the ability to produce gasoline, the octane number 95 for nominal capacity of 30,000 b/day, a catalytic conversion, has a greater range of

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capacities various applications are used to produce 95 octane gasoline. For a maximum capacity of 170 ton/hr, this temperature has the ability to produce gasoline with an octane value of 6/98, which can be made by applying minor changes such as increasing the temperature of the stabilizing tower Catalytic converter unit or increase the ratio of hydrogen to hydrocarbon or a slight increase in inlet pressure the reactors achievedpetrol with an octane number of 95 [16-19].

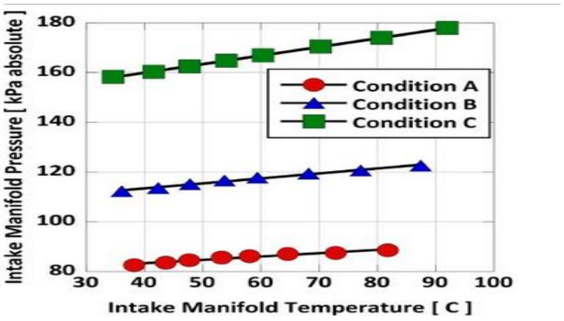

Figure 1. Effect of reactor input temperature changes and unit capacity on gasoline octane number

Investigation the Effect of Reactor Input Temperature Changes on Yield Volume Rate and Gasoline Octane Number

One of the important parameters that should be considered in increasing the temperature to improve the octane number is the percentage of volumetric gasoline yield, which plays a significant role in determining the limit of the maximum permitted reactor input temperature [20]. In the catalytic conversion process is the volume ratio of the product to the feed. The purpose of this study is to continue to identify the factors limiting and affecting the process of increasing the number of octane gasoline to find optimal operating conditions. The test was conducted at constant capacity of 137 ton/hr of refined heavy naphtha, equivalent to 27500 bpd, and a constant flow of 800 kg/hr of catalyst. The input temperature of the reactors is independent and the volatility and octane number of the gasoline product are dependent variables [21-25].

The review and observation of the results show a decrease in the yield volume of the product in exchange for an increase in the reactor input temperature. As noted earlier, due to the high energy required for hydrocracking reactions, with increasing temperature, the rate of this type of adverse reactions increased significantly and the larger molecules, due to the hydrogen breakdown, converted to smaller molecules and consequently due to increased production of lighter products such as petroleum gas, the percentage of volatile gasoline output is reduced. Based on the results, the optimal input temperature of the catalytic converter reactors is based on the proposed conditions in the range (535-520 °C).

Investigation the Effect of Changes in the Mole Ratio H_2/HC on the Amount of Gasoline Octane Number and the Amount of Coke Content Formed on the Catalyst

The variable H_2/HC is the molar ratio of hydrogen in the return gas to the input hydrocarbons of the continuous catalytic conversion unit. As seen, high hydrogen pressure is required to prevent coke formation [26-28]. Pressure is maintained by returning a part of the hydrogen output. There are also some C_1-C_5 hydrocarbons in the return gas. It is clearer at the start of the hydrogen operation. [29] The effect of increasing this molar ratio on dehydrogenation reactions and carbonization of paraffin’s by dehydrogenation is relatively reducing the reactions. Expecting a decrease in gasoline octane number in exchange for an increase in this molar ratio goes. This test was carried out at a constant capacity of 150 ton/hr of heavy refined naphtha feed of the catalytic converter unit, and the input temperature of the reactors was equal to 525 °C and a constant flow of 800 kg/hr of catalyst flow. The mole ratio H_2/HC is independent and the percentage of coke formed and the gasoline octane number is dependent variables [30].

As expected, by increasing the molar ratio, the amount of coke content formed on the catalyst is reduced. But the results, in relation to the effect of increasing this molar ratio on the octane number, are, contrary to expectations, an increase in the gasoline octane number. In justifying this, firstly, it should be noted that the dehydrogenation and carbonization of paraffin are not completely equilibrium. On the other hand, by increasing the molar ratio H_2/HC, the amount of catalyst flux decreases, which leads to an increase in the speed of desired reactions to increase the octane number [31]. In addition, because of the flood of circulating gas, the furnace heat transfer to the catalyst bed of the reactors is increased and the reactor core temperature is increased and the temperature difference of the reactors is reduced. This situation is similar to the increase in the input temperature to the reactors, as a consequence of the higher temperature rise of the substrate reactors, and as a result, the octane number rises due to the high concentration of optimal octane reactions. From the observation, it can be concluded that in the above mentioned conditions, the molar ratio of H_2/HC higher than 2.5 in order to increase the octane number and reduce the percentage of coke formed is optimal and appropriate. Usually, however, lower molar ratios of H_2/HC are preferred. The increase in this ratio will reduce the export and dispatch of hydrogen produced by the catalytic converter unit and increase the consumption of equipment such as the return gas compressor and increase the total unit energy consumption, such as the heat load of the furnaces, and to reduce the number of favorable reaction octane is not cost-effective and desirable [32-35].

Investigation the Effect of Reactor Pressure Changes on Gasoline Octane Number and Coke Content Formed

This test was carried out at constant temperature of 525 °C and fixed capacity of 150 ton/h of refined heavy naphtha feed and the returning hydrogen gas with a constant flow of 22 ton/hr with a purity of 90% and a constant mass flow of catalyst at 800 kg/hr [36].

As can be seen from figure 4-8, with increasing reactor pressure, gasoline octane number decreases and also the amount of coke content formed on the catalyst is reduced. As noted above, at high pressures, the amount of coke is low compared to other reactions, but at low pressures it is significantly increased that will happen in the catalyst converter unit of the Octanizer. In general, results show that the operation is more suitable at low pressure. Because the cracking rate is reduced and the amount of cycling is as high as the amount of coke formation. On the other hand, based on the thermodynamic laws, there is a further improvement in the low pressure of dehydrogenation and cycling reactions, which leads to an increase in the octane number. Also, at higher pressures, the rate and amount of undesirable hydrocracking reactions are also increased. The only weak point of low pressure is the high rate of coke formation, which is also compensated by the continuous catalyst recovery operation. On the other hand, increased operating pressure requires higher compressor power consumption and the use of pipes and fittings with higher thickness and high pressure bearings and consequently, it is more expensive, which itself increases the cost of capital and operations. Using the results of this study, it is possible to calculate the optimal operating pressure before applying the guessing and error in the operating unit, which is always associated with exorbitant costs, in various conditions. On the basis of results, the optimal operating pressure is suggested to be about 5.5 relative bar, with an octane number stabilized at a slight increase of about 47.99 and a coke percentage of 3.9 in the acceptable and appropriate range. At present, in the continuous catalytic converter unit of refinery with a capacity of 150 ton/hr, the exhaust gas pressure of the compressor is maintained at about 5.6 relative bar.

Investigation the Effect of Reactor Input Pressure Changes on Volumetric Yield Rate and Coke Catalysts

In order to complete and increase the accuracy of the optimization of the results of the previous review, the observation of the effects of the independent operating pressure variable on the efficiency limiting parameter in the decision-making process regarding optimal pressure seems useful. This test was carried out at constant temperature of 525 °C and fixed capacity of 150 ton/hr of refined heavy naphtha feed and the returning hydrogen gas with a constant flow of 22 ton/hr with a purity of 90% and a constant mass flow of catalyst at 800 kg/hr. The reactor input pressure as the independent variable and the gasoline volumetric yield percent and the percentage of coke formed on the catalyst as the dependent variable are determined.

With increasing pressure, due to the speed and rate of hydrocracking reactions, the rate of yield or, the amount of gasoline is reduced. Therefore, the increase in pressure, in addition to reducing gasoline octane number and increasing the cost of capital and operational, also has the loss of reduced product returns. Based on the results of this study and considering the volumetric and coke percentage values, the optimum return pressure range of the compressor gas returning is recommended to be about (5.2-6.1) relative bar at a capacity of 30,000 b/day.

Investigation the Effect of Weight Concentration of Chloride (Catalytic Acid) on Octane Number and Coke Content formed on Catalyst

This agent is produced by adjusting water and chlorine on the base of catalyst alumina. To maintain the correct catalyst acidity, there must be a balance between the circulation of water in the circulating gas and the catalyst level chlorine. This system makes it possible to accurately control the acidity of the catalyst surface when the unit is in service. A certain amount of acidity of the catalyst base is required to provide some desired reactions (such as isomerization and cycling), which results in maximum optimal efficiency. The proper function is in some way influenced by the optimal acidity of the catalyst. The catalyst acidity depends on the amount of chlorine that is determined during the catalyst construction phase. During operation, the amount of chlorine catalyst is changed by the circulating gas and the washing of chlorine by water, which occurs essentially during the coke burning process. For this reason, the catalytic acidity level should be adjusted during chlorination and kept within the optimum weight range.

With these interpretations, it is considered necessary to study the optimum concentration of catalyst chloride weight in various operating conditions. This study was carried out in a fixed mass flow rate of 150 ton/hr of refined heavy naphtha feed and a constant temperature of 525 °C, reactor input and circulating gas flow constant of 22 ton/hr and a flow of 800 kg/h catalyst flow. Independent variable catalyst chloride concentration and octane number and coke content formed on the catalyst surface are also dependent variables of this experiment.

It can be obtained by increasing the concentration of chloride (acidic agent) of the catalyst, increasing the amount of gasoline octane number, and coke formed percentage on the catalyst will also be upward. The catalyst acidity leads to desirable reactions of linear paraffin isomerization and positive carbonizing reactions of paraffin by dehydrogenation. Therefore, increasing the octane number for increasing the chloride concentration is a consequence of this logical review. On the other hand, negative hydrocracking reactions were attributed to the acidic agent, which justifies the upward trend in the proportion of coke relative to the increase in chloride weights.

According to the results presented, the optimum amount of catalyst chloride weight in the process conditions considered, and according to the changes in the octane number and the percentage of coke formed in the range (0.9-1.5) weight percent is recommended. In addition, at this concentration of chloride, the octane number is desirable to 95. In higher concentrations, the octane number is not significantly changed, but the intensity of coke formed percentage is increased.

Investigation of the Effect of Chloride (Catalytic Agent) Concentration Weight on of Gasoline Mass Yield

Due to the importance of efficiency in catalytic conversion processes, the study of the effect of chloride percentage weight changes on the mass yield returns is helpful in finding the optimum range. So, this issue has been addressed. In addition, because of the important role determining the limiting factor of the coke content, it is necessary to observe these effects along with its changes. This study was carried out in a fixed mass flow rate of 150 ton/hr of refined heavy naphtha feed and a constant temperature of 525 °C, reactor input and circulating gas flow constant of 22 ton/hr and a flow of 800 kg/h catalyst flow. Independent variable catalyst chloride concentration and mass fraction efficiency and coke content formed on the catalyst surface are also dependent variables of this experiment.

It can be concluded that the mass yield of the product decreases for increasing the chloride weight percentage. The reason for these results can be expressed in an increase in undesirable hydrocracking reactions. The result is to determine the optimum range (0.3-3.1) by weight percentage of the catalyst chloride in the operating conditions and based on the yield and coke formation effects.

Analyzing the Effect of Chloride (Acidity) Catalyst Concentration Weight on the Percentage of Hydrogen Purity of Circulating gas

The importance of the purity parameter of hydrogen circulating gas is due to its effect on the percentage of coke formed on the catalyst. The higher the purity of the gas is, the lower the percentage of the coke to form. As a result of studying the effects of this variable along with the coke, it can be useful to find the optimal concentration of chloride in the catalyst. This study was carried out in a fixed mass flow rate of 150 ton/hr of refined heavy naphtha feed and a constant temperature of 525 °C, reactor input and circulating gas flow constant of 22 ton/hr and flow of 800 kg/hr catalyst flow. Independent variable catalyst chloride concentration and hydrogen purity percentage of circulating gas and coke content formed on the catalyst surface are also dependent variables of this experiment.

It can be concluded that by increasing the catalyst chloride weight percentage, the purity of hydrogen circulating gas decreases, which is due to an increase in undesirable hydrocracking reactions, which leads to an increase in light gas combinations. The result of this investigation is to find the optimal range (0.3-1.3) weight percent of the catalyst chloride concentration under the operating conditions and based on the purity of hydrogen circulating gas and the percentage of coke formed.

Investigation the Effect of Reactor Input Temperature Changes on Energy Consumption of Catalytic Conversion Unit Furnaces

One of the most important parameters and factors of industrial unit’s optimization in their design and exploitation is the economic indicators issue, which is the most pronounced in energy consumption issues. In this study, initially, at nominal capacity of 30,000 b/day under conventional conditions, the effect of furnace temperature changes on the total amount of heat required for furnaces was investigated, and then the energy consumption was calculated for an octane number increase. Then, the energy efficiency optimization solutions aimed at fixing the octane number 95 in nominal capacity have been investigated. This study was carried out in a fixed mass flow rate of 150 ton/hr of refined heavy naphtha feed and a circulating gas flow of 22 ton/hr with a purity of 90 percent hydrogen and a flow800 kg/hr catalyst flow. Meanwhile, the catalyst chloride concentration is controlled at 1.1% by weight percentage. The reactor input temperatures are the independent variables and the total thermal bar consumed by the furnaces and gasoline octane number are dependent variables.

Conclusion

By observing the results obtained, it is clear that increasing the reactor input temperature to reach the desired octane number also increases energy consumption. In this chart, the highest slope in the increase of energy consumption in relation to the increase in the reactor input temperature is from 470 to 515 °C, which is equivalent to increasing the octane number from 78 to 97. To calculate the amount of energy needed to increase a unit octane number in each conditions of this test.

It can be seen, that in nominal capacity and the conventional conditions, the greatest increase in the furnaces thermal bar at 495 °C occurred to reach the octane number 87.6 to 89.8 and the maximum energy consumption per rise an octane unit is 1872 kw at 515 °C to reach the octane number 96.8 °C. Also, the table below shows the average energy consumption per unit octane, equal to 1422 kw, with a nominal capacity of 150 ton/hr and the conventional conditions announced. In this capacity and conventional conditions, 105800 kw of energy for furnaces thermal bar is needed to achieve the octane number of 95 at 530 °C.

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