
STUDY OF THE EFFECT OF A COSTANT MAGNETIC FIELD ON THE DISPERSED AND PARAMAGNETIC PROPERTIES OF THE FEEDSTOCK IN THE CATALYTIC CRACING PROSES

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Abstract: *The impact of a continuous magnetic field on the yield of the end products and the overall effectiveness of the catalytic cracking process utilizing granulated OMNIKAT-210P catalyst in a fluidized bed has been thoroughly investigated. According to experimental studies, the impact of the magnetic field on the catalyst and the feedstock during the catalytic cracking process intensifies the reaction course and greatly boosts process efficiency. The direction of catalytic conversions has been found to become more selective when subjected to a magnetic field, which increases the production of high-octane gasoline fractions and other premium light petroleum products. Consequently, the use of a magnetic field makes a significant contribution to raising the caliber of the goods that are produced as well as the technological performance of the catalytic cracking process.*

Keywords: *catalytic cracking, tar, vacuum gas oil, catalyst, gasoline fraction, magnetic field, selectivity, inductivity.*

INTRODUCTION

The extensive exploitation of conventional raw material supplies, which causes their slow depletion while simultaneously creating a steadily increasing demand for light petroleum products, especially motor fuels, is a defining feature of the modern petroleum refining business. The effective processing and deep conversion of heavy oil dregs to boost the production of premium fuels that the industry needs has taken on particular significance in this regard. Both energy security and the more sensible use of petroleum resources depend heavily on the resolution of such issues. Catalytic cracking is regarded as one of the most popular and extensive technological procedures in the refining of petroleum [1, 2].

A significant percentage of motor fuels, particularly gasoline fractions, can be produced thanks to this technique. One of the best and most effective ways to carry out the catalytic cracking process is to employ a fluidized bed of catalyst. The process's main objective is to generate valuable hydrocarbon gases that may be utilized as feedstock in the petrochemical sector in addition to high-octane gasoline components. In order to meet the growing demand for fuel resources in industry, the catalytic cracking process must be intensified. Process intensification is often accomplished by the development of novel catalysts with high activity and selectivity, constructive reactor modifications, and technical advancements [3].

These methods, however, are not always economically viable in current

manufacturing facilities and need a large financial outlay. Particular focus has been placed on finding other, reasonably priced ways to speed up the catalytic cracking process in recent years. A promising method in this respect is the initial application of a magnetic field to the catalyst and feedstock. The feedstock and catalyst's structural, dispersive, and physicochemical qualities are influenced by a magnetic field, which has a favorable effect on the process's trajectory, the target products' yield, and their quality attributes [4, 5].

EXPERIMENTAL PART

The current paper summarizes the findings of theoretical and experimental research on how a magnetic field affects the condition of vacuum gas oil as well as the makeup and characteristics of the byproducts that are produced during catalytic cracking. Granulated OMNIKAT-210P was employed as the catalyst, and vacuum gas oil that boiled between 350 and 520 °C was chosen as the feedstock. Under the influence of a continuous magnetic field with an intensity of 0.25 T, the catalyst and vacuum gas oil samples underwent first treatment. The results of the study show that applying a magnetic field is a viable strategy for boosting the catalytic cracking process's efficiency [6].

Table 1

Physico-chemical characteristics of vacuum gas oil

Name	Indicators
Group chemical composition, mass %	
Aromatics	44,5
Resins	3,2
Paraffins	50,9
Fractional composition	°C
Initial Boiling Point	295
10% recovery	315
30% recovery	355
70% recovery	425
90% recovery	472
Metal content, %	
Nickel	0,2
Vanadium	0,8
Sulfur content, %	0,6
Conradson carbon residue, mass %	0,5

We carefully examined the physical and chemical quality attributes of the products produced during the catalytic cracking of vacuum gas oil, both in the presence of a magnetic field and in the absence of one. These studies' findings demonstrated that petroleum processing is considerably more efficient when treated in a magnetic field, yielding better results in terms of product yield, quality metrics, and overall process efficacy.

The magnitude of magnetic induction, the rate at which the processed liquid crosses the magnetic field in the active zone (the region with maximum induction), and the frequency of liquid intersections with the magnetic field were found to be the

primary factors influencing process efficiency when a magnetic field is applied to hydrocarbon and water systems.

Table 2

Quality characteristics of the OMNIKAT-210P catalyst

Name	Indicators
Chemical composition, mass %	
Rare earth metal oxides	1,6
Micro-activity after steam stabilization	71
Bulk density, kg/m ³	615
Na ₂ O	0,32
Al ₂ O ₃	40
Surface area, m ² /g	189
Platinum	0,00019
Pore volume, cm ³ /g	0,43

These parameters jointly affect the molecular structure, viscosity, and dispersive characteristics of the petroleum feedstock, consequently enhancing the efficiency of the catalytic cracking process (table 1).

Consequently, magnetic treatment modifies the physicochemical characteristics of the feedstock and facilitates the generation of superior-quality products in the catalytic cracking process. This leads to diminished energy and resource utilization and enhances the optimization of processing activities in industrial applications [7,8].

RESULTS AND DISCUSSION

Illustrates the schematic diagram of the laboratory setup intended to investigate the influence of a magnetic field on the catalytic cracking process. This configuration has been meticulously crafted to thoroughly examine the interaction between the feedstock and the catalyst, the process parameters, and the effects of the magnetic field (table 3).

The entire setup is nitrogen-purged prior to system startup. Since oxygen can interfere with the catalytic cracking process and result in undesirable oxidation reactions, this step aims to exclude all oxygen from the reactor. In order to efficiently collect and remove oxygen, nitrogen is fed through a specific reactor that has been pre-filled with copper filings. This guarantees that the reactor's inside is inert. After that, the reactor is put inside a furnace, which steadily maintains the necessary process temperatures.

The setup's reactor is composed of quartz. The reaction zone has an interior diameter of 30 mm and a volume of 30 cm³. The best possible contact between the catalyst and the feedstock is guaranteed by these dimensions. An autotransformer and an automatic temperature control system are used to reach the necessary process temperature (7). The ideal temperature for catalytic cracking, 500 °C, is used for the experiments.

A specialized liquid pump is used to transfer the feedstock mixture into the reaction zone. This pump minimizes process variations by ensuring a steady and uninterrupted feedstock flow. To ensure the best possible contact between the catalyst and the feedstock throughout the reaction, the feedstock flow rate is set at 1 h⁻¹.

Study of the effect of a constant magnetic field on the dispersed and paramagnetic properties of the feedstock in the catalytic cracking process

In order to efficiently collect and remove oxygen, nitrogen is fed through a specific reactor that has been pre-filled with copper filings. This guarantees that the reactor's inside is inert.

Table 3

Comparison of the quality of vacuum gas oil cracking products under the influence of a magnetic field and under normal conditions

Product Indicators	Without magnetic treatment	In a magnetic field
Gasoline		
Octane number	82	84
Density at 20 °C, kg/m ³	743,8	732,7
Sulfur content, mass %	0,12	0,8
Dry gas		
CO content	0,33	0,31
Sulfur content, %	0,9	0,8
C ₃ and C ₄ , mass %	11	7
Propane-Propylene Fraction		
Sulfur content, mass %	0,21	0,019
Propylene content	42,8	44,7
C ₄ content, mass %	6,4	7,1
Butane-Butylene Fraction		
Sulfur content, mass %	0,19	0,015
C ₃ content, mass %	3,5	4,7
C ₄ content, mass %	29,7	37,4
C ₅ content, mass %	2,6	3

After that, the reactor is put inside a furnace, which steadily maintains the necessary process temperatures.

The quartz reactor is filled with prepared granulated OMNIKAT-210P catalyst (table 2). The catalyst granules have an average diameter of 2 mm. At the bottom of the reactor, a layer of quartz filler measuring 1-2 cm³ is applied to guarantee even flow distribution and correct catalyst positioning. Next, a further 2–3 cm³ layer of quartz infill is applied on top of the catalyst. The quartz contacts grains' average diameter is also 2 mm, guaranteeing even heat dispersion and homogeneous flow inside the reaction zone.

The reactor packed with catalyst is put into quartz furnace 2. The furnace's cylindrical shape guarantees uniform heat dispersion. Thermocouples are used to measure the temperature at the top, middle, and bottom of the catalyst bed. To provide precise readings, a chromel-alumel thermocouple is used for measurements and put in a special thermocouple pocket. Controller 3 prevents abrupt thermal shocks to the catalyst and feedstock by progressively increasing the reactor temperature to the target level.

The reactor and furnace are placed between the poles of an electromagnet (15) when it is necessary to investigate the impact of the magnetic field. These poles produce a uniform magnetic field in the reactor zone. The strength of the magnetic field is 0.25 T. The rectifier (16) is used to accurately control the current, which in turn controls the

magnetic flux. This makes it possible to accurately assess how the magnetic field affects the distribution and composition of catalytic cracking products.

As a result, the setup that has been provided enables the catalytic cracking process to be conducted in a variety of situations, both in the absence of a magnetic field and in the presence of one, while offering exact control over process parameters. This lab configuration is perfect for methodically investigating how temperature and magnetic field affect catalytic cracking.

The feedstock from the reservoir is injected into the reactor zone in a vapor-liquid state once reactor 1 reaches the predetermined temperature. A specialized liquid pump is used in this process to provide a steady and uninterrupted feedstock flow. After passing through a pre-heater, the feedstock is warmed to the ideal temperature for the reaction when it enters the reactor zone.

An autotransformer is used to accurately regulate the pre-heater's temperature. This guarantees that the reaction parameters stay constant and that the feedstock enters the reactor zone at the appropriate temperature. A specialized data logger is used to continually record temperature values throughout the reaction, enabling precise real-time process tracking. In the reactor, the catalytic cracking reaction takes place within the preset parameters and circumstances. The reactor temperature and the feedstock flow rate directly affect how the reaction proceeds. Hydrocarbons are broken down and divided into different fractions by the catalyst's contact with the feedstock.

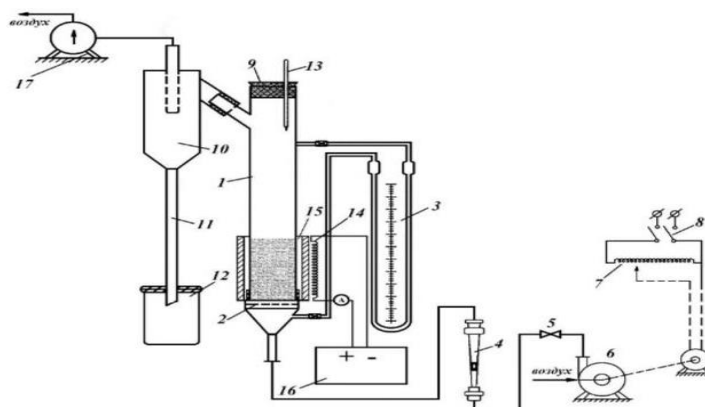


Fig.1. Schematic diagram of the laboratory setup for studying the effect of a magnetic field on the catalytic cracking process: 1 – reactor, 2 – metal mesh, 3 – diaphanometer, 4 – rotameter, 5 – control valve, 6 – air fan, 7 – autotransformer, 8 – potentiometer, 9 – plug, 10 – cyclone, 11 – riser, 12 – storage tank, 13 – thermometer, 14 – magnetic coil, 15 – magnetic core, 16 – adjustable power supply, 17 – gas meter

The end products are removed from the reaction zone and sent to a cooling system once the reaction is finished. The goods are effectively chilled in this method before being gathered in receiving tanks. This phase is essential for the products' appropriate storage and for getting them ready for further examination. The goal of the next experimental studies was to examine how the magnetic field affected the catalytic cracking process. In particular, the impact of a 0.25 T magnetic induction on vacuum gas oil catalytic cracking was investigated. Three different tests were carried out for this purpose: 1. The magnetic field was only applied to the catalyst.

2. The magnetic field was only applied to the feedstock.
 3. The catalyst and the feedstock were subjected to the magnetic field simultaneously. As a result, the impact of the magnetic field was assessed independently in each instance, and comparisons were made with respect to fraction composition, process productivity, and other performance metrics. Table 4 provides a detailed presentation of the experimental findings on the impact of the magnetic field on the catalytic cracking of vacuum gas oil at 450°C.

Table 4

Influence of Magnetic Field (MF) on the Catalytic Cracking (CC) process of vacuum gas oil (T=450°C, V=1.0 h⁻¹)

Indicators	VGO without MF	Magnetic treatment		Feedstock (+), Catalyst (-)
		Feedstock (+), Catalyst (+)	Feedstock (-), Catalyst (+)	
VGO	100	100	100	100
Obtained, mass %				
Fraction IBP - 185 °C	32,1	34	40,4	41,5
Fraction 185-350 °C	21,2	19	23,5	22,1
Fraction above 350 °C	25,8	26,3	20,3	23,5
Liquid products	81	82	86	82,4
Cracking gas	14,6	13,6	10,3	10,5
Losses	1,8	1,8	1,7	1,8
Conversion	73,5	71	78,8	78,6
Coke	3,1	3,1	2,9	2,9
Total light fractions	53,5	54	63,8	63,6

Note: (+) indicates that it was subjected to a magnetic field, whereas (-) indicates that it was not. The comprehensive findings of research on the impact of the magnetic field on the catalyst, the feedstock, and the combined treatment of both are shown in table 4. These studies carefully assessed how the magnetic field affected the fraction composition, process productivity, and product quality attributes.

These findings suggest that the impact of the magnetic field on the catalyst and the feedstock can result in notable modifications to the productivity of the reaction and the make-up of the final products.

CONCLUSION

According to the experimental data, the yield of liquid products improves dramatically to 85.0% when the catalyst alone is subjected to the magnetic field. Concurrently, the overall percentage of light fractions increases to 64.2%, which is 10.5% higher than the baseline. The catalyst's increased activity in the magnetic field and the feedstock's improved interaction with the catalyst are responsible for this improvement. Positive improvements are also shown when just the feedstock is subjected to the magnetic field: the yield of liquid products increases to 83.5%, and the overall light fraction content rises by 10.3% to 64.0%. This indicates that the preliminary treatment of the feedstock in a magnetic field plays a significant role in enhancing the productivity of the catalytic cracking process.

The yield of light petroleum products is 54.2% when the catalyst and feedstock are treated simultaneously in a magnetic field; this is nearly identical to the yield of

untreated vacuum gas oil. This finding implies that the combined effects may occasionally partially offset one another, leading to little or no increase in the total yield of the product. The hydrocarbon makeup of gasoline fractions is also significantly altered by the magnetic field's effect. In particular, the content of aromatic hydrocarbons falls by 15.1% by mass, but the quantity of isoparaffins and olefins rises by 6.1% and 11.7% by mass, respectively. These modifications raise the percentage of high-octane gasoline fractions and enhance fuel quality.

In addition to increasing process efficiency, applying a magnetic field lowers the process temperature from 500°C to 450°C. This increases the yield of target products by 5–15% by mass while lowering energy usage.

According to the study's findings, the catalyst treated in a magnetic field produced the best results. The yield of light petroleum products (diesel and gasoline fractions) increased by 10.5% when pure vacuum gas oil was catalytically cracked, whereas the yield increased by 17.7% by mass when a vacuum gas oil combination was catalytically cracked. According to these findings, pretreatment of the catalyst in a magnetic field is a viable and efficient way to maximize process productivity and product quality.

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