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HYDROTREATING OF KEROSENE FRACTIONS IN THE PRODUCTION OF JET FUELS

The features of hydrotreating processing of kerosene fractions are considered. Usage of more effective catalyst for the production of high-quality jet fuel is offered.

Розглянуто особливості процесу гідроочищення газових фракцій. Запропоновано використання більш ефективного каталізатора для одержання високоякісних реактивних палив.

catalyst, hydrocracking, hydrotreating, jet fuel, sulphur removal

Introduction

Jet fuels during their storage, transporting and using can cause corrosion of metals and alloys, used in the fuel systems of airplanes. The products of combustion of jet fuels are able to demonstrate corrosive action. The corrosive aggressiveness of fuel depends on character and amount of sulfur, nitrogen and oxygen compounds. As a result of high corrosive activity of mercaptanes, their quantity in jet fuels is strictly limited. It is also principal reason of low stability of jet fuels, that is why such fuels are undergone to hydrotreating process [1].

Analysis of researches and publications

Hydrotreating is a single-stage process which proceeds in most soft, in comparison conditions to hydrocracking and destructive hydrogenization. There is partially destructed mainly sulfur-organic and partly oxygen- and nitrogen- containing compounds. The products of decomposition by saturation with hydrogen are H₂S, water, ammonia and unsaturated or aromatic hydrocarbons.

The catalysts of hydrotreating are compounds of oxides and active components (nickel, cobalt, molybdenum and other) with with a participation of transmitter for which most frequently used the activated oxide of aluminium. A transmitter action is not only to be an inert diluent but it also takes part in forming of active phases, and also serves as structural promotor that creates a specific porous structure, optimal for processing of specific raw material [2].

A process proceeds as follows. Raw material is mixed with hydrogen-containing gas with concentration 85–95 % vol., that enters from the circulations compressors, which support pressure in the system.

The mixture is heated in a oven to 280–340 °C, depending on raw material, then enters reactor.

Reaction passes over catalysts, which contain nickel, cobalt or molybdenum, at pressure up to 50 atm. In such conditions there occurs destruction of sulfur and nitrogen compounds with formation of the H₂S, ammonia, and olefines. Mixture of products outflowing from the reactor, becomes separated from the surplus of hydrogen-contained gas in a separator, that returns into circulation compressor. Hydrocarbon gases are separated and the product enters fractional column from the bottom of which product is pumped out (cleared fraction) [1].

Industrial assembles have much general in apparatus design and to the construction of reactor blocks and they differentiate on capacity, sizes of details, technological mode and to the charts of sections of separation and stabilization of hydrogenization and also, by the variants of usage of hydrogen-contained gas: with circulation or without circulation «on a channel».

The assembly of service of hydrogen-contained gas «on a channel» is used only in the combined assembles of hydrotreating and catalytic reforming process (with the stationary layer of catalyst and hydrogen conducted under the higher pressure).

It is easy to support permanent correlation of hydrogen: raw material in a assembly with circulation of hydrogen-contained gas. The presence of circulation compressor allows to regulate required multiplicity of circulation of hydrogen-contained gas, enables to conduct the gas-air regeneration of catalysts.

There are two methods of separation of hydrogen-contained gas which are used for gas-air mixture: cold (low temperature) and hot (high temperature).

Cold separation of hydrogen-contained gas is used in assembles of hydrotreating, fractioning of kerosenes and sometimes for diesels of petrols; it consists in cooling of gas-air mixture which flow out from the reactors of hydrotreating. Hot separation of hydrogen-contained gas is used mainly in the assembles of hydrotreating of high-boiling fractions of oil; fuels of diesels, vacuum gas oils, oil distillates and paraffins.

On refinery are applied the followings two variants of regeneration of the saturated solution of mono -

ethanolammonia:

- directly assembling of hydrotreating
- the centralized regeneration in an the all-factory knot[2; 3].

Formulation of tasks

Hard requirements to quality of oil products , in the first turn on the decline of maintenance of sulfur and aromatic hydrocarbons, force to search more effective catalysts of hydrotreating.

Decision of task

Hydrotreating of kerosene is used with the purpose of production of jet fuel with contents of sulphur to 0,1 %. The process of hydrotreating is conducted on an active catalyst with pressure to 7MPa, in such conditions due to hydrogening of aromatic connections and their contain notably diminishes to the necessary value. The catalysts of hydrotreating show by itself compounds of oxides of active components (nickel, cobalt, molybdenum and other) with a transmitter. There are of special interest catalysts of firms of Criterion Catalyst (C-448), Haldor Topsoe (TK-554, TK-907, TK-908), AKZO Nobel (KF-752).

Assemble of hydrotreating consists of the followings blocks :

- Reactor block;
- Block of stabilizing of hydrotreating fraction of 140 – 280 °C with the section of preparation of fuel PT;
- Block of cleaning of hydrogen-contained gas .

Hydrotreating of fraction of 140 – 280 °C is carried out on of TK-575 (Haldor Topsoe firm) at the temperatures from 300 to 370 °C and at pressure of 4,0 MPa and in the environment of hydrogen-contained gas. The reactions of transformation of sulfur-, nitrogen- and oxygen-contained compounds run across in a reactor with the stationary layer of catalyst [4].

Using this catalyst in the process of hydrotreating of kerosenes has next advantages:

- maintain excellent performance over a wide range of operating variables such as liquid and vapour loads;
- superior performance also when tray is not perfectly level during operation;

- self-cleaning nozzles require less maintenance and thereby improve performance;

- easy and fast installation to save time;

- minimum required reactor height provides more space for catalyst in the reactor;

- an unmatched number of drip points and coverage ensures improved utilisation of the catalyst, even at the reactor wall;

- innovative mechanical support system for tray plates so they are less likely to warp under load as compared to traditional beam supported trays.

The liquid distribution tray and quench mixers are the most crucial elements of reactor internals design in order to ensure efficient catalyst utilisation.

The vapour-lift distributor tray distributes the vapour and liquid evenly across the entire cross section area of the catalyst bed (fig. 1).

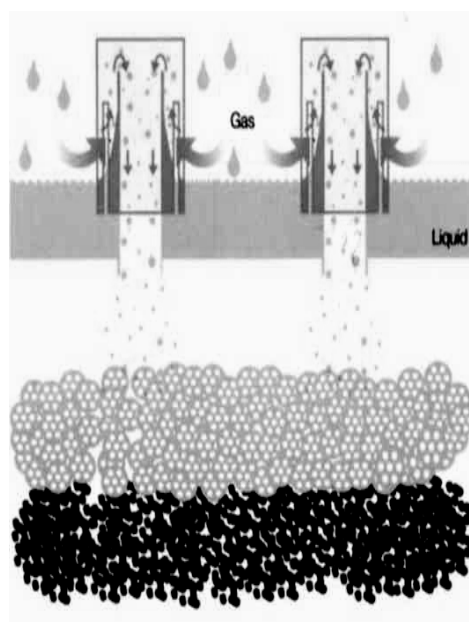


Fig. 1. The operational principle of Topsoe's VLT tray

These trays operate on a vapour assisted principle by which the vapour flow through the nozzles creates a pressure differential. This lifts liquid droplets from the tray and carries the liquid and the vapour up through the riser and down through the downcomer to the catalyst bed below. The vapour lift mechanism for liquid flow results in even flow distribution, because the liquid flow is not sensitive to the local liquid level at the nozzle.

In contrast to the VLT tray, a chimney tray achieves liquid flow by means of gravity. Thus, the flow through a chimney depends greatly on the liquid level at the chimney.

Comparison between the typical required vertical height for Topsoe's VLT tray of the previous generation design.

The design of VLT trays includes the capacity to retain fouling material without affecting liquid and vapour distribution and thereby catalyst performance (fig. 2).

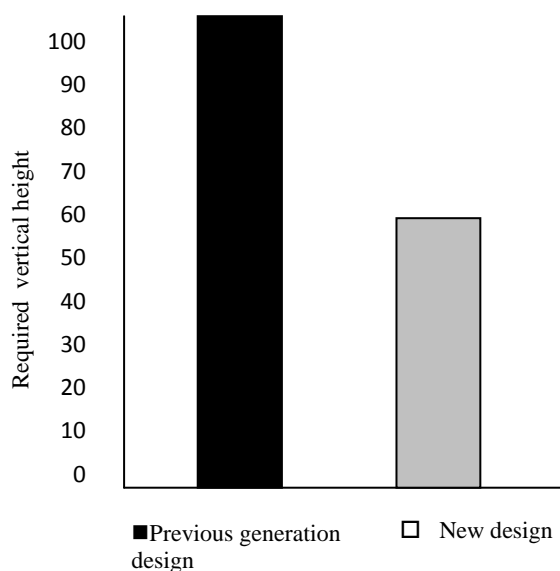


Fig.2. Comparison between the typical and VLT tray

The slotted nozzles are self-cleaning (fig. 3). By design, the velocities through the slots do not allow fouling materials to settle in the slot and thus always provide enough cross sectional area to ensure that the flow paths are kept clear for the vapour and liquid mixed phase flow. In two-phase hydroprocessing reactors, a mixing device is required between the catalyst beds.



Fig. 3. Self-cleaning nozzles of catalyst

A well-designed mixing device ensures good contact between the quench fluid and the vapour and liquid effluent from the catalyst bed above. This results in efficient heat and mass transfer with uniform composition and an even temperature profile in the bed below. Any non-uniformity created by a poorly-designed mixing device will result in loss of reactor efficiency. In two-phase hydroprocessing reactors, a mixing device is required between the catalyst beds. A well-designed mixing device ensures good contact between the quench fluid and the vapour and liquid effluent from the catalyst bed above. This results in efficient heat and mass transfer with uniform composition and an even temperature profile in the bed below. Any non-uniformity created by a poorly-designed mixing device will result in loss of reactor efficiency. The Topsoe Vortex-type quench mixer is used extensively throughout the refining industry. The Topsoe Vortex-type quench mixer is a state-of-the-art design now being used extensively throughout the refining industry. Comparison between tray deflection at typical design loads for a traditional beam supported distribution tray and Topsoe's new design for a reactor with an inner diameter of 4,400 mm (illustration is not to scale). The new design ensures better flow distribution [5].

Conclusion

The process of hydrotreating of kerosenes, described higher, allows to get high-quality jet fuels, responding to requests of all specification parameters.

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