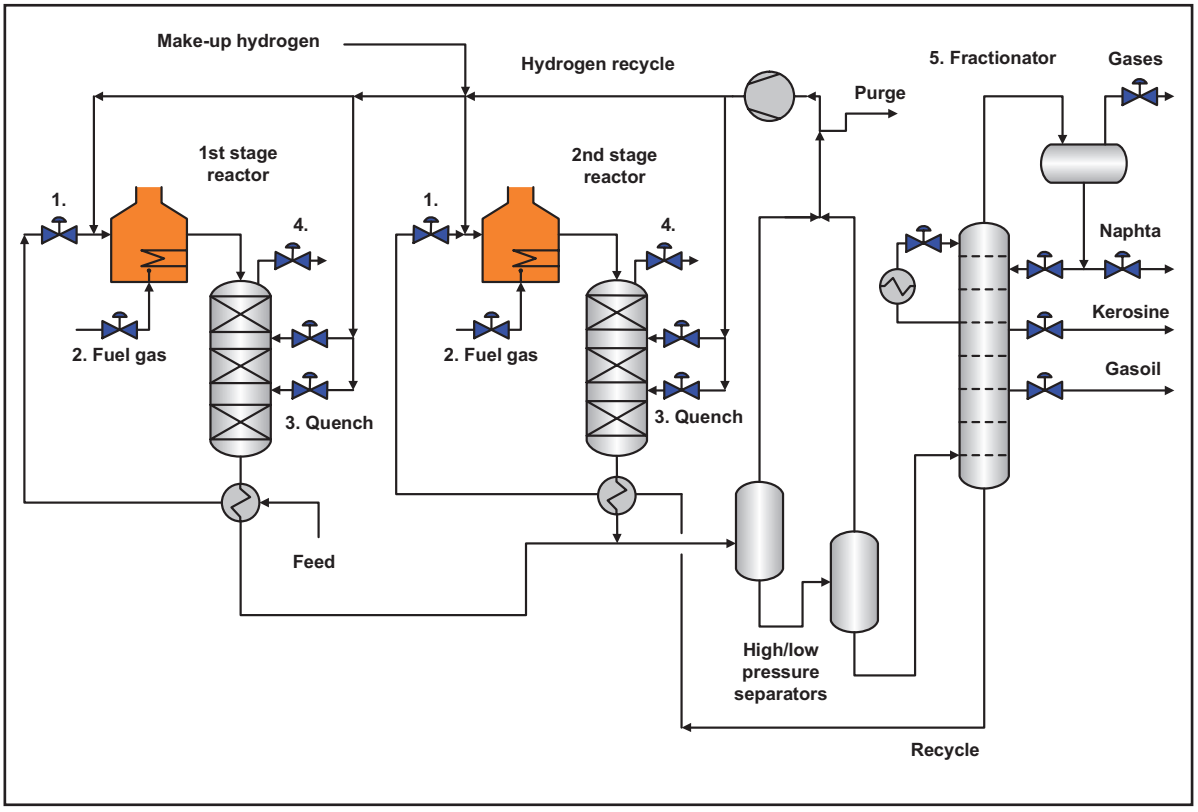
Hydrocracking



Process overview

Demand for gasoline and diesel is increasing, while the demand for heavy-oils, such as fuel-oil is declining. Refiners are therefore taking more steps to convert heavy oils into lighter distillates. Hydrocracking can significantly improve refining margins by upgrading low-value products into higher-value, high-demand products.

Typical hydrocracking feedstocks include heavy atmospheric and vacuum gasoils, and catalytically or thermally cracked gasoils. These products are converted to lower molecular weight products, primarily naphta or distillates. Sulphur, nitrogen and oxygen removal and olefin saturation occur simultaneously with the hydrocracking reaction. Typical reactor operating conditions require temperatures of 280 – 475 °C and reactor circuit pressures of 35 – 215 bar depending on the feedstock and final products desired. The reactions consume hydrogen and are highly exothermic. The key to hydrotreating and hydrocracking reactions is applying bi-functional catalysts that contain an acid function and a metal function.

Various process configurations have been developed, which can be classified as single-stage, two-stage and series-flow hydrocracking. The differencies between these configurations are partial or complete conversion of feed to lighter products, type of catalyst and process selectivity towards contaminants and final product types. The above process flow diagram describes a 30 000 bpsd two-stage, full conversion through recycling of unconverted product and it is widely used because of its efficient design resulting in minimum cost for full-conversion operation.

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Hydrocracking challenges

Top class products – The objective of hydrocracking is to convert heavy hydrocarbons into high-quality lighter products. The most important part of the cracking process is the catalyst system and reactor temperature control. The reactor temperature must be increased throughout the cycle to maintain conversion as the catalyst deactivates due to unavoidable coke formation on the catalyst surface. Constant depletion of hydrogen requires adding fresh hydrogen to the system. Surplus heat released by the hydrogenation reactions causes the reactor temperature to increase. To control this by injecting cold hydrogen quench is important in order to avoid catalyst fouling and safety risks.

Health, safety, environment – Many refiners provide an operating margin for emergency conditions by maintaining a significant load on the feed furnace to maintain good control on reactor inlet temperature, ensuring that control valves for the hydrogen quench are not fully open and maintaining a reserve quench gas rate. Valve performance can be one of the weakest links in the safety system, where the failure mode is being stuck. The only way to test for this condition is to stroke the valve regularly, but closing the valve completely is not desirable when the unit is operating. In many refineries hydrocracker reactor can be a SIL 3 application.

Maintenance costs – Poorly performing valves in the process must be serviced because they will have a direct impact on the efficiency of the process. The cost of unscheduled maintenance will be quite high, up to 70 % of the cost of a new valve in some applications. Add this to the cost of removing the valve from the line and disruption of the process and the total cost will be much higher. Typical hydrocracking plant runtime is 2 to 4 years when the catalyst will need regeneration of the deposits. This requires reliable equipment and process control.

Metso solutions

We are all tuned up to answer these challenges through our refining application experience and product offering for control, safety and automated on/off duty that ensure high valve performance in hydrocracking.

Safety – Rotary stem operation reduces fugitive emissions and leakage. Packing construction meets the latest emission standards. Our products are fire tested and apply to the latest standards.

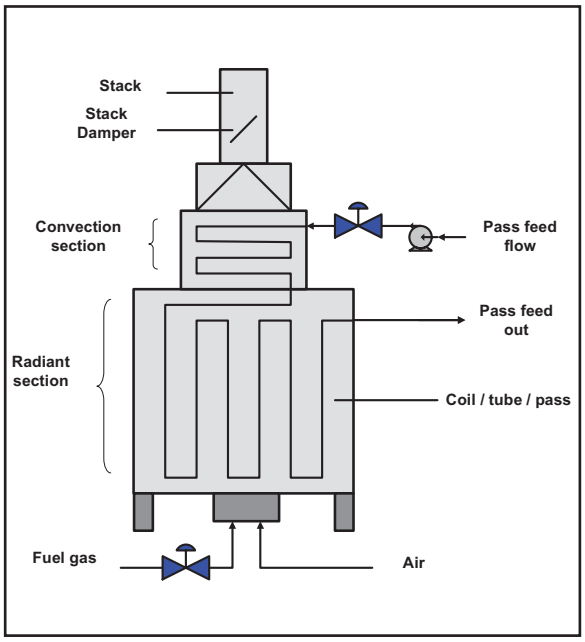
Efficiency – Reduce throughput losses with excellent valve performance by reduced variability and no product leakage through rotary stem. Flow through the process may be changed as needed with high rangeability up to 150:1 and further with full bore valves.

Availability – Rotary valves have been in service for several years without requiring maintenance and show no sign of leakage. We offer our customers full flow control support with global sales, project management and service network.

Reliability – With our on-line condition monitoring the valve performance can be tested without disturbing the process. This will increase the operational reliability and safety with valves throughout the process including reactor temperature control in preventing reactor temperature.

Heater applications

Energy-efficient heater operations involve proper control, maintenance and monitoring of process fluid outlet temperature, draft, excess air and fuel-firing rate. In multipass heaters it is important to control the flowrates for optimum residence time. Leaking valves will result in valve sticking and poor control behaviour. 1 % fuel savings in a 3000 MMBtu/day hydrocracking heater saves approximately 60 000 USD/year in fuel cost.



1. Heater pass flow control

Challenge – Problems with this valve can reduce heater performance and throughput control. Severe problems can limit the unit throughput and reduce conversion. A significant change in feed flow rate can result in a temperature runaway in the reactor due to rapid change of the hydrogen-to-hydrocarbon ratio.

Metso Solution – Finetrol eccentric plug rotary valve for moderate temperature service (< +425 °C) and Top entry valve for high temperature (> +425 °C).

Benefits – Customers report remarkable savings in maintenance costs after installing our control valves. Oil leaking through gland packing has been avoided, and this improved operator safety in the plant and reduced emissions to environment. Heater efficiency was improved. Average saving in maintenance costs on a 4-year process cycle is approximately 38 000 USD/valve.

Finetrol

2. Heater fuel gas control

Challenge – Reliability and accuracy is required from heater fuel gas control. It has a direct impact on the process performance, since the heater outlet temperature is controlled by fuel gas to the burners. Variations in the fuel gas composition have an affect on the heating value and fuel-gas pressure at burner. A failure in the system may shutdown the whole process. Excessive temperature of the heater outlet can result in temperature runaway in the reactor.

Metso Solution – Finetrol eccentric plug valve for general fuel gas control, RE-series segment valve for high capacity applications and Rotary globe for low capacity applications.

Benefits – Single valve solution due to wide rangeability – no need for split range control. Reliable control and reduced variability improves heater energy efficiency and heater temperature control and therefore process control.

RE-series segment valve

Reactor applications

3. Reactor bed quench

Challenge – This is an important control for the conversion of the unit and reactor bed temperatures. The cold hydrogen quenches injected between the catalyst beds in the reactor are controlled to obtain equal bed outlet temperatures at lowest average bed temperature. This minimizes the catalyst deactivation rate, maximizes product selectivity and conversion. The bed inlet temperatures are typically kept within ± 1.0 °C of setpoint without excessive tuning adjustments. The flow control minimizes disturbances to the bed inlet temperature originating in the hydrogen system hydraulic balance. During the run period, the temperature is gradually raised daily to compensate for catalyst activity loss and maintaining reaction severity. Transparency to valve performance is highly desirable in this application. Total hydrogen consumption in a 30 000 BPSD hydrocracker is about 1000 scf/bbl → yearly cost for hydrogen is about 33 million USD/year.

Metso solution – Rotary globe valve (ASME 1500).

Benefits – Economic benefits will be achieved by optimizing the hydrogen usage. This can be achieved by reducing the hydrogen quench variability that ensures equal temperatures at catalyst beds. Variability reduction with ND9000 valve controller from ± 1.0 °C to ±0.5 °C can reduce hydrogen consumption yearly about 450 000 USD. This gives potential to improve the process economics even further. More efficient catalysts may be used since more active catalysts require control system that will respond faster with less process variable dead band. Therefore the unit production can be increased. Process safety can be improved by ND9000 on-line diagnostics that provides full transparency to valve performance. Wide rangeability with rotary valves ensures that hydrogen flow can be increased as need arises during the run period due to catalyst activity loss and reserve capacity for emergency quench is available with single valve solution.

Rotary globe

4. Reactor depressuring

Challenge – Many refineries are looking for safety instrumented function for their hydrocracking process unit's emergency depressuring upon detecting thermal runaway. Many hydrocrackers are equipped with two different means of depressuring: a slow system and a fast system. In an emergency scenario, an operator will first attempt to bring the process under control using the slow depressuring and only use fast depressuring system if the other is not capable of stopping the runaway reaction from continuing. The process can be brought back to safe state by either manual or automatic depressuring. In order to minimize the negative impact on the process equipment, the slow depressuring is always attempted first.

Metso solution – T-series top entry valve (up to ASME 1500).

Benefits – Fire-safe construction and on-line valve diagnostics ensure reliable and safe valve operation so that the process can be brought back to safe condition. Long lasting metal seat tightness, rotary stem and live-loaded packing reduces the emissions to environment and product losses. Patented Q-trim design provides up to 18 dB(A) noise attenuation where noise level is to be reduced during depressuring. For emergency depressuring ValvGuard intelligent safety valve controller is available as option.

T-series

Fractionator applications

5. Fractionator control valves

Challenge: The purpose of distillation is to separate the different boiling fractions, obtain final or 95 % boiling point purity of the product streams at minimum required energy and maximum product yield. The efficiency of the distillation depends on the contact between the rising vapour and the liquid falling down through the column. Column control parameters, such as stripping steam, pressure control and circulating reflux depend on each other and the changes to the feed quality entering the column.

Metso Solution: Finetrol eccentric plug valve for general control applications, Segment valve for high capacity applications and Neldisc butterfly valve for large sizes.

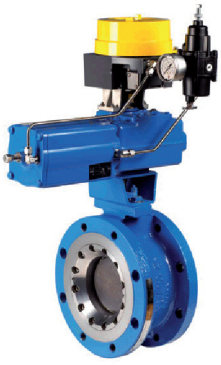
Benefits: With our control valves the product variability can be reduced. This provides optimum product quality and yield with no additional energy requirements. Valve plays a significant role in control loop, especially when high loop performance is targeted. Better valve performance means increased profit to the refinery. Long lasting metal seat tightness minimizes product losses and emissions to the environment.

Finetrol

Summary

Optimize your plant safety and hydrocracking performance, reduce energy and maintenance costs and produce top-class products with our intelligent rotary control, on-off and ESD-valves.

Neles intelligent valve controllers



Visibility to switching applications

Reliable ESD -solutions

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