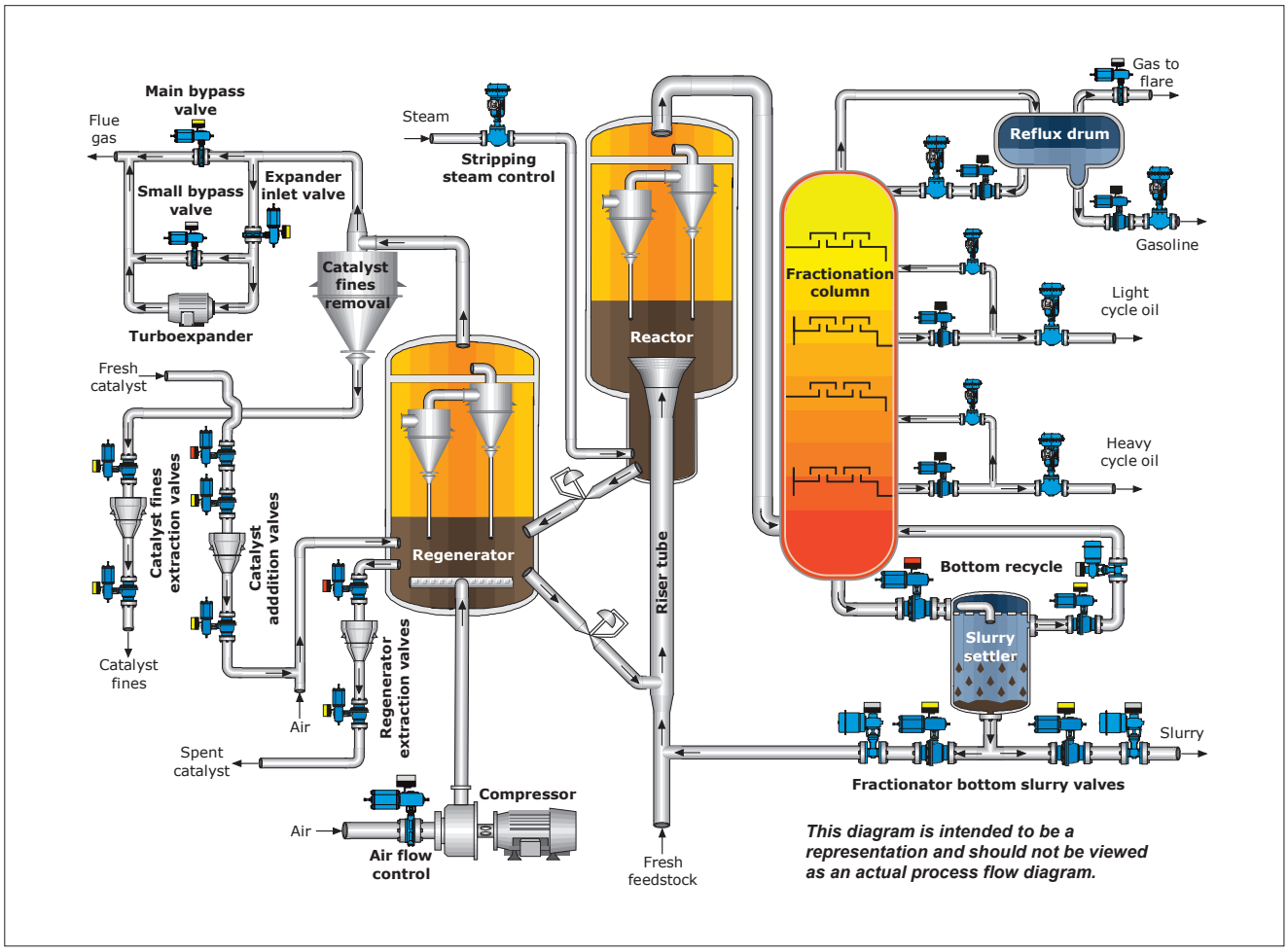
Fluid catalytic cracking



Process overview

Fluid catalytic cracking (FCC) is an important and widely used process to convert heavy feedstock into lighter, more valuable, products. Various feedstocks can be used such as gas oils, vacuum gas oils or residual materials. Typical products are gasoline, light fuel oils and olefin-rich gases.

Hot catalyst from the regenerator flows in a fluidized state through the riser tube into the reactor. The incoming feed together with recycled slurry start vaporizing and cracking even before entering the reactor with the help of a catalyst. The cracking reaction continues until the catalyst and the feed are separated in the reactor.

While the reactions take place, coke is formed on the catalyst. The spent catalyst is separated from cracked material and is regenerated by burning off the coke. The exothermic combustion reaction raises the temperature of the catalyst to around 620-850 °C (1150-1550 °F). After regeneration, the catalyst is sent back to the reactor and the absorbed heat is transferred over to the incoming feed.

The cracked hydrocarbons enter a fractionation column, where they are separated into gasoline, light cycle oil, heavy cycle oil and slurry. The gasoline product has good overall octane characteristics, suitable to be used for gasoline blending.

Fluid catalytic cracking applications

Continuous catalyst regeneration makes it possible to manage the high catalyst coking rate. A constant yield is achieved by cycling the catalyst between the reactor and the regenerator, which ensures the reactor is continuously supplied with freshly regenerated catalyst. Catalyst handling valves play an important role in ensuring proper FCC performance. Reliable and accurate control, on-off and ESD valve performance is important for total process efficiency.

Stripping steam control valve

During cracking reactions, hydrocarbons are adsorbed on the catalyst. Before entering the regenerator, part of the adsorbed hydrocarbons are removed from the catalyst by steam stripping.

The dilution steam supply valve typically requires accurate control to minimise the steam consumption and noise reduction capabilities. The steam supply to the reactor takes place as dry saturated steam.

Neles™ solution for stripping steam

Neles globe valves with a spring diaphragm actuator and an ND intelligent valve controller are well suited for controlling steam.

- **Best possible control accuracy** to optimise steam consumption
- **Excellent reliability,** ensuring effective oil stripping
- **A variety of trims available,** including the Tendril design, reducing noise and eliminating cavitation
- **Identify maintenance needs in advance** with the ND smart positioner for condition monitoring

Neles globe valve

Air flow control

The cracking process also produces coke which sticks to the catalyst particle and rapidly lowers its activity. To maintain catalyst activity, it is necessary to regenerate the catalyst by burning off this coke with hot air. Regeneration is a key part of the FCC process.

It is critical to control the regenerator temperature carefully to prevent catalyst deactivation by overheating and to provide the desired amount of burn-off. This is done by controlling the air flow. A typical air temperature is around 430-540 °C (800-1000 °F).

Neles solution for air flow control

Neldisc™ high performance triple eccentric disc valve with a pneumatic actuator and an ND intelligent valve controller offers the best solution for controlling air flow.

- **Assured tightness over long periods,** due to unique full metal seat design
- **Mechanically induced disc and seat contact,** making tightness unrelated to differential pressure
- **Thermal cycling resistant** with bi-directional tightness even in large cycling
- **Highly modular design** and material selection for ease of maintenance and valve selection
- **Economical control valve** for low differential pressures

Neles disc valve

Catalyst extraction valves

Spent catalyst is extracted from the regenerator into a lock hopper where it is made inert before removal. Some catalyst is also carried by the hot flue gases exiting from the top of the regenerator. This catalyst is separated in a cyclone and then enters another lock hopper before removal. In each case, the lock hoppers have isolation valves beside them so that the catalyst can be made inert.

Catalyst handling valves require reliable and leak free isolation to improve efficiency and meet environmental standards. The valve must also be able to resist build-up of catalyst particles in cavities. A typical temperature is around 600-760 °C (1100-1400 °F).

Neles solution for catalyst extraction

Neles seat supported ball valve with solids proof seat, a B1-series pneumatic actuator, and a SwitchGuard valve controller as an option.

- **Solids proof seat,** preventing catalyst dust from getting behind the seats
- **Self-scraping seat design,** as the seat and the ball are in continuous contact effectively wiping the seat every cycle
- **Emission proofing,** as live loaded packings are available as standard
- **Special hard coatings available,** making the valve applicable in the most difficult of cases
- **Reach fast stroking times without accessories** such as volume boosters or quick exhaust valves, due to the high pneumatics capacity of SwitchGuard

Neles ball valve

Catalyst addition valves

Each day, several tons of fresh catalyst are added to replace losses through cyclones and extraction in order to maintain the catalyst to feedstock ratio at an optimal level. The new catalyst passes through the first valve into the lock hopper. The first valve, above the lock hopper, is then closed and the second valve, below the lock hopper, is opened admitting the new catalyst into the process.

Catalyst friendly design and tight-shut off are required. Fire safe design is also often required. The added catalyst is typically at ambient temperature.

Neles solution for catalyst addition

Jamesbury™ soft-seated ball valve with Xtreme seats, a B1-series pneumatic actuator, and a SwitchGuard valve controller as an option, has been proven to be the right choice for catalyst addition valves.

- **Xtreme™ seat,** a fluoropolymer-based blend, which provides longer life, expanded performance boundaries and greater value
- **Bubble tight shut-off** even after a million cycles, due to the flexible lip seat design which prevents permanent deformation from occurring
- **Fire-Tite™ design,** meeting API 607 and BS6755-Part 2 requirements
- **Configure to meet process demands** – SwitchGuard gives the possibility to set the on-off valve stroking times and profiles according to the process needs
- **Practise predictive maintenance** with the help of the extensive diagnostics that SwitchGuard provides on the catalyst valve performance

Jamesbury ball valve

Slurry isolation valves

The fractionator bottoms is a mixture of heavy cycle oil and catalyst fines. Optimizing process efficiency requires that as much as possible of this catalyst is recovered and recycled to the process. There are four different methods utilized for recovering the catalyst fines: slurry settlers, tank settling, mechanical filters or electrostatic filtration. Slurry settlers are the least efficient, thus most new capacity and upgrades utilize some other method.

Regardless of the method chosen for fine recovery, the main challenge for valves is the abrasive nature of the fluid that is being processed due to very high solids content. The temperature of the bottom slurry is also relatively high, around 310 °C (590 °F). In mechanical filtration systems, several vessels are operated in parallel and they are sequentially switched between filtration and backwashing by utilizing isolation valves. This requires a valve and actuator construction capable of delivering a high amount of cycles.

Neles solution for slurry isolation

For slurry isolation valves, **Neles seat supported ball valves** with high temperature metal seats and special hard coatings.

- **Durable and long lasting tightness** up to ANSI class V as standard by utilizing metal seats
- **Abrasion resistance,** by applying a Nickel Boron coating to the ball and Chromium Carbide (CrC) coating for the seat
- **Thermal transient resistant,** due to the body and ball being constructed of A351 CF8M, ensuring the longest possible life and seat to ball tightness
- **Tested and field proven** – the valves have been proven to withstand over a million cycles annually
- **Longer operational life** with the unique spline driver construction as it minimizes contact stress, also yielding a more economical and safer process

Slurry control valves

Recovered slurry with catalyst fines is recycled back to the riser tube to be mixed with the incoming feed so that the catalyst can be reused. The recycle is also used to recover heat for feed preheat through kettle boilers and exchangers. This fluid is known as catalyst oil slurry.

Due to its highly abrasive nature and relatively high temperature its control is a very demanding valve application. Depending on the location at the slurry circuit, the temperature of the bottom slurry can be between 150 and 370 °C (300 and 700 °F).

Neles solution for slurry control

For control valves, **Finetrol™ eccentric rotary plug valves** with flow to close direction offers an excellent and economical solution in most cases.

- **Stellite internals as standard,** providing excellent abrasion resistance
- **Reduced fugitive emissions by design,** as the valve utilizes rotary operation which is inherently less prone to leaks
- **Improved energy efficiency,** as reliable control reduces process variability

In extreme erosive cases. **Neles ceramic ball valves** offer one of the most erosion resistant designs available today.

- **All-ceramic wetted parts,** ensuring the best possible erosion resistance
- **Thermal shock resistant,** eliminating the need for careful warming/cooling of the piping
- **Proven to last in the most difficult of conditions,** as the valve has lasted five times longer in operation compared to competitor solutions

Finetrol eccentric rotary plug valve

Expander valves

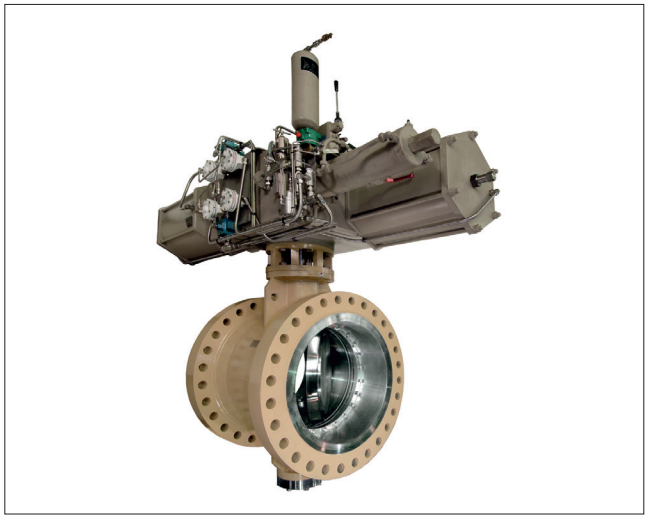
The flue gas from the FCC process exiting the regenerator has a high pressure, temperature and volume, making it a potential source of energy. Using a turboexpander allows this energy to be recovered with good efficiency, and this energy can then be used e.g. to drive the air compressor. The expander inlet valve controls the upstream pressure to keep the regenerator pressure constant. The main bypass valve is normally closed and is only opened in case of an expander trip. The small bypass valve is used for synchronizing the expander and overspeed control. It remains in intermediate control in normal operation.

The expander valves should be able to work under a very high temperature (up to 760 °C/1400 °F). The flue gas may entrain some abrasive catalyst particles. Fast closing/opening, suitable shut-off capabilities and reliability over long periods are required. During emergency cases, huge thermal shocks may lead to very high pressure loads on the valve seat.

Neles solution for expander valves

Neles B-series butterfly valves for high temperature and pressure applications. For lower temperatures, **Neles L-series butterfly valves** are a robust and economical solution.

- **Triple eccentric design,** reducing friction and wear
- **Thermal shock resistant,** keeping its tightness even in large thermal cycling
- **Abrasion resistant** as the solid metal seat is based on metal-to-metal contact
- **No resilient parts exposed to the medium,** ensuring a lasting performance
- **Extremely high cycle life,** saving maintenance costs and increasing process uptime



Neles B-series butterfly valve

Benefits

- Increase productivity with accurate control
- Save maintenance costs with robust and lasting valve designs
- Emission proofing to meet local regulations
- Increase process uptime
- Eliminate the risk of valves getting stuck due to particle accumulation
- Save piping and valve costs with compact and lightweight valve solutions
- Reliable catalyst regeneration improving total process efficiency

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