

Made to measure



Sabrina Nees, Berthold Technologies, Germany, looks at the ways in which level control can be improved under the extreme conditions of a fluid catalytic cracking unit.

Catalytic cracking is one of the most important conversion processes used in petroleum refineries. It is a widely used process in refineries for converting heavy oils into gasoline and lighter products. Originally, cracking was accomplished thermally, but the catalytic process has almost completely replaced this, as it produces higher octane number gasoline and less heavy fuel oils and light gases. Fluid catalytic cracking (FCC) operates at high temperatures and low-pressure conditions. The feedstock is injected into a catalyst which circulates between reactor and regenerator to ensure efficient conversion. It converts heavy gas oil from atmospheric distillation and other streams to light gases, petrochemical feedstock, gasoline blendstock (FCC naphtha) and diesel fuel blendstock. The cracking process produces coke as a side product which remains on the catalyst surface and lowers its activity. It is important to regenerate the catalyst by burning this coke in air. The cracking reaction itself is endothermic and regeneration is exothermic. Hence the regeneration heat can be used to supply the heat needed to preheat the feed to the reactor.

Measurement based on attenuation

In order to control the entire cracking process, level measurements are essential. In fluid catalytic cracking units (FCCUs), level measurement poses some challenges for the manufacturers of process measuring instruments. These include, in addition to the risk of blockages, extreme process conditions such as high temperatures. Such extreme conditions make radiometric measurements indispensable. The measuring principle of radiometry is based on the attenuation of radiation when penetrating materials. A detector measures the radiation emanating from a radioactive source and attenuated by the material in the vessel, whereby the resulting signal can be assigned to a corresponding measured value, by means of a

calibration. Thereby source and detector are mounted on the opposite side of the vessel. A typical arrangement would entail a rod detector and point sources (as shown in Figure 1). By mounting the system components on the outer wall of the

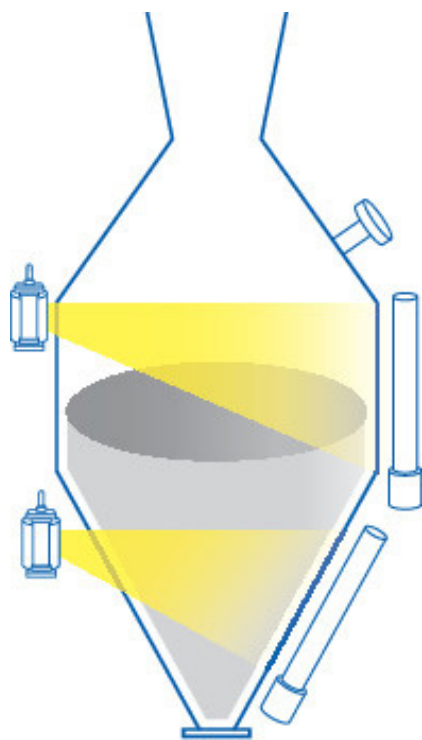


Figure 1. Typical arrangement of a radiometric level measurement.

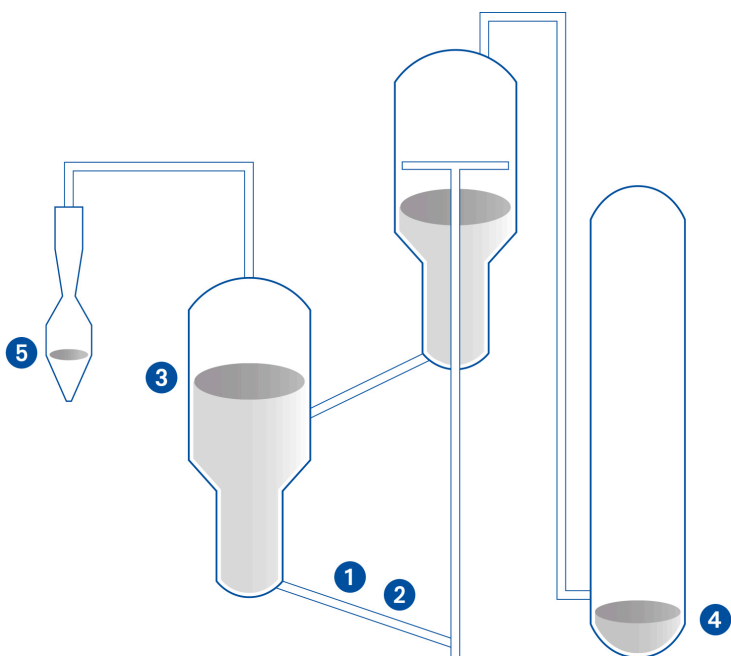


Figure 2. Measurement solutions for the optimisation of FCCUs: 1) density measurement of catalyst in the regenerated standpipe; 2) level measurement of catalyst in the regenerated standpipe; 3) level measurement in the regenerator; 4) level measurement in the distillation column; 5) level measurement in the cyclone separator.

vessel, they are easy to install even on existing vessels, without modifications or process downtimes.

Shielded sources for non-contact measurements

Due to their high sensitivity to gamma radiation, efficient detectors can be operated with very low source activities, which is important for a customer's health, safety and environment (HSE) programme, and also a major cost-saving factor. The most common nuclide used for this application is Caesium-137, whereby the radioactive material is safely sealed in an absolutely tight and durable capsule, which guarantees safe handling – even under extreme measurement conditions. In addition, the capsule is safely housed in a shield made from steel or stainless steel and filled with lead or tungsten or both. Such a shield offers an excellent shielding effect in every possible situation. The shield (or rather the shutter) remains closed until the measurement is put into operation, which ensures safe handling from a radiation protection point of view.

Rod detectors with special features

By the use of rod detectors, measuring ranges of up to 12 m and installations at the bottom conical part of the reactor are possible. A one-time calibration of the system as part of the initial commissioning is sufficient, and recalibration is not required. Automatic stabilisation technology based on cosmic radiation, as used by the manufacturer Berthold, leads to high repeatability and long-term stability, useful for continuous processes such as modern FCCUs which operate 24 hr/d for up to 3 to 5 years. A reliable measurement is vital for the operation of a process. The influence of interference radiation on the measurement, e.g. by weld inspections, can be reduced to a minimum by using sophisticated algorithms. At Berthold, such algorithms are used in the 'X-Ray Interference Protection' (XIP) and 'Radiation Interference Discrimination' (RID) features and thus implemented in the detectors. This secures a safe process and makes refiners independent from actions that might even occur in neighbouring plants. Modern detectors can also be used in safety critical processes. The company's SENSseries detectors are certified for use in SIL2 applications, and even SIL3 is achieved with homogenous redundancy. The certificate covers all measurement applications, from high level or low level alarms to continuous level and density measurement. Therefore, safe operation of critical processes can be guaranteed.

Non-contact measurement

Since mechanically moving parts are not installed, and the system components do not come in contact with the material to be measured, radiometric systems are wear-resistant and maintenance-free. The measurement is almost independent of other process conditions, such as vessel size, build-ups or installations in the vessel. Radiometric level measurements can be applied on several sections, e.g. on the cyclone separator, on the regenerator, electrostatic precipitation hoppers and on the regenerated standpipe (see Figure 2). The ability of the radiometric devices to measure solid catalyst under the high temperatures needed in an FCCU, makes it the ideal measurement solution to maintain safe and reliable operation.

Level of catalyst fines in cyclone separator

Catalyst fines have to be removed from the regenerator flue gas to fulfil regulatory requirements, protect downstream equipment, and for reuse. Cyclonic separators are then used to extract the remaining catalyst fines. The solid particles settle down at the bottom of the separator, where their level can be controlled by radiometric level systems. The fines are removed when the catalyst level exceeds 70% and the valve is closed again when the level drops below 10%. It is important that there is always catalyst in the bottom part, serving as a plug for the hot gas stream. A reliable level measurement of the catalyst is mandatory for this process step, simply to retain control of the valves. In addition, a doubly-redundant level switch measurement at the bottom part of the reactor is useful for safety-critical aspects. The non-contacting technology is ideally suited for this kind of application since dust and temperature have no impact on the measurement performance. Reliable control of the fine level improves the catalyst removal and ensures an ideal utilisation of the vessel capacity.

Fractionator tower bottom level

Vessels that are ideal for the use of radiometric devices in the FCC besides cyclone separators are electrostatic precipitation hoppers and the fractionator tower bottom level. The hydrocarbon fluid in the FCC distillation column, also known as the fractionator, is at about 350°C and very viscous. Refiners aim to keep a constant level of the residue at the bottom of the column. If the level is too high there is a risk of liquid overflowing into the upper fractions, deteriorating the product quality or leading to contaminations. On the other hand, the highest possible level extends the residence time of the

product in the column and more of the volatile components are evaporated, which increases the efficiency of the process. If the level is too low, the pumps can cavitate, which leads to severe damage to the pump seals or the pumps themselves. Radiometric level measurements on the fractionator tower bottom, unlike other methods like differential pressure, are not affected by changing catalyst fines percentage, viscosity or high temperatures, and are therefore convincingly reliable.

Further applications

In an FCCU, the measurement of the fluidised bed in the standpipe can be a requested measurement task, too. Level as well as density of the fluidised catalyst can be measured with radiometric measurement systems.

Conclusion

To improve the process control of an FCCU, level measurements are necessary. For level measurements in FCCUs, radiometric measuring systems compared to other methods, such as methods based on the simple buoyancy principle or radar measurements, offer some obvious benefits that justify the use of radioactive sources. In petroleum refineries, aggressive atmospheres, high pressure, and extreme temperature processes require technology that can withstand these harsh conditions while delivering accurate results. Radiometric measuring systems can offer non-contact, reliable and robust operation. The level measurement under extreme conditions is therefore an ideal application example for radiometric measurement systems, such as the systems from Berthold. With measuring solutions based on gamma absorption, the refiners are equipped to reliably control their processes and ensure safe operation, maximising efficiency and profit. 