Techniques employing gamma radiation to investigate process problems have been available for many years. Most commonly, a radiation source is positioned externally on one side of a vessel with a gamma detector on the opposite side. They are synchronously lowered down the vessel, measuring the amount of radiation passing through the vessel for a few seconds every few inches of elevation. Gamma emitting tracers are also injected into processes to follow the pathways of flowing fluids, gases and solids using stationary detectors. Both of these techniques rely on a moving radioactive source.

There is another application of gamma radiation that does not involve the movement of the source or detector. Known as stationary monitoring, the source and detector are positioned diametrically opposite each other on a vessel or pipe. Changes in the density of material passing between the source and detector are monitored by measuring detector count rate over time. The most common use of this technique is to identify the process rate at which flooding occurs in a distillation column. If a TRACERCO Diagnostics™ - Scan identifies flooding, the rates can be reduced to unload the vessel and then stationary monitoring can be used at the position of the flooding while the rates are slowly increased to find the condition that initiates the problem. This allows operators to maximize production, while remaining below the rate at which flooding begins.

In processes where density control is essential, such as solids handling, stationary monitoring offers a way to monitor for any fluctuating density. This information can help identify the causes of circulation problems and aid in optimizing corrective actions.

Continued on page 2
Case History

A US Refinery had been through a revamp and there was a desire to better understand how the FCCU was operating. A series of tests was designed to gather information about flow patterns, distribution, residence time, and aeration densities of the catalyst and vapors in various parts of the FCC. Tracerco was contacted to help gather this information.

One part of this project was to investigate the performance of the aeration steam in the Regen Cat Standpipe. Operations had indicated that the flow of regenerated catalyst was unstable. Figure 1, shows the Regen Cat Standpipe above the expansion joint. There are four steam nozzles on this portion of the Standpipe.

Tracerco was asked to perform a TRACERCO Diagnostics™ - Scan of the Regen Cat Standpipe to determine the average density of the catalyst and steam mixture flowing down the Standpipe. The source and detector were aligned at the top of the standpipe and synchronously lowered. Figure 2, shows the results of this scan. The reduction in intensity of the radiation passing through the standpipe is related to the density of the mixture via an inverse exponential function. Therefore, the more radiation counts, the lower the density of the mixture and the less radiation counts, the greater the density. The vertical scale shows the distance from the top of the exposed standpipe.

The scan indicated that density across the Regen Cat Standpipe was fluctuating as evidenced by the spikes of high radiation counts (low density). This scan is not only a scan in elevation but in time as well, each measurement consisting of a 3 second accumulation of data at each elevation. The results indicated that stationary monitoring was needed to obtain a better understanding of the fluctuations in density over time.

Figure 3 shows the results of stationary monitoring at four elevations on the first day; first at the two extreme positions, then two additional positions to pinpoint the location of concern. The results (blue line), at 7 feet above nozzle 1, were very spiky, indicating rapid fluctuations in density. The next elevation, at the nozzle 4 elevation, showed a very consistent density (red line). The results (green line) at the third elevation nozzle 2, indicated the density was fluctuating, but less severely than above nozzle 1. The last position was at the nozzle 1 elevation. These results (black line) showed more intense spikes than at nozzle 2, but not as intense as above nozzle 1.

Taken together, the results indicated that some of the steam entering at nozzle 1 was being drawn down with the downward flowing catalyst, as expected, but that the steam was disengaging from the catalyst and forming bubbles that rose countercurrent to the catalyst flow.

Figure 3 Stationary monitoring scans at four elevations were performed the first day. Scan results indicated that some of the steam entering at nozzle 1 was being drawn down with the downward flowing catalyst, as expected, but the steam was disengaging from the catalyst and forming bubbles that rose countercurrent to the catalyst flow.

Figure 4 After adjustments had been made to the steam flows, the density below nozzle 1 was reasonably low and very consistent, as seen in Figure 4.

Continued on page 5
Flowrate Measurements Are Used To Identify Problems In A Regeneration Column

By Xiao Ying – Senior Engineer, Petrochina Liaoyang Petrochemical Company in collaboration with Dr. Stuart Charlton, Company Scientist, Tracerco and Shyh Seong Yong, Tracerco China - Business Development Manager - Shanghai, PRC

Radioactive Tracer Techniques

Tracers used to troubleshoot refinery and petrochemical plants generally consist of gamma ray emitting radioisotopes incorporated into liquids, gases or solids. The penetrating radiation that they emit can be detected outside of process vessels. This means that many radiotracer applications can be performed without the need to take samples... a very worthwhile simplification when studying process materials that may be toxic, corrosive, at elevated temperature or high pressure. Radioisotopes that are employed are generally of short half-life, so that there is no residual radioactivity in the system after the measurements are complete.

Flowrate Measurement

The use of radiotracer techniques for the measurement of flow rate is one of the most common and most useful applications. Although there are several ways in which this can be done, there are two techniques that have been found to be particularly applicable to studies on process plant: the “pulse velocity” and “dilution” techniques.

The basic equipment arrangement for pulse velocity measurement is shown in figure 6. A sharp pulse of appropriate radiotracer is injected into the process stream using any convenient injection point, such as a pressure gauge. Two radiation detectors are positioned sufficiently far downstream of the injection point to ensure that by the time the tracer has reached the first detector it is completely mixed across the flow profile. The distance between the two detectors is measured accurately. As the tracer pulse passes the detectors, they respond to the presence of the radioactivity and their output signals are sent to a data analyser. The time between the centroids of the response curves is the mean transit time of the tracer between the detectors and from this and the detector separation, the flow velocity is calculated. The linear velocity can be converted to volume flowrate by multiplying it by the mean cross-sectional area of the process line.

The pulse velocity technique requires that the flow in the pipeline be turbulent and completely fill the pipe bore. Though turbulent flow must be present for the dilution flow technique to be effective, full-bore flow is not a requirement. Here, radio-active tracer is injected at a known and controlled rate into the flow to be measured. Samples are taken downstream and by computing the radiotracer mass-balance the volume flow rate of the process stream is calculated. In this method, there is no need to know the cross sectional area of the pipe… indeed, it is often applied to the study of flows in conduits of irregular and uncertain cross section, such as rivers, open conduits and drainage ditches. Since the dilution flow technique requires knowledge only of the injection flow rate, the tracer concentrations in the injection material and the samples, it is a very direct method of flowrate measurement.

Nevertheless, the pulse velocity technique is the more commonly used of the two because it is easier to apply and provides an immediate answer.  

Continued on page 4

Figure 6 – Illustrates the basic equipment arrangement for the pulse velocity measurements.
Flowrates
(Continued from page 3)

There are many situations in which on-line measurement of flow can be valuable:
1. To provide data for the computation of mass balance across a plant or unit.
2. To check or to calibrate an installed flow meter.
3. To measure flows in parts of a plant that have no installed flow meters.
4. To measure the efficiency of pumps and turbines.
5. To measure the distribution of flow in a network.
6. To measure discharges to the environment.

However, some of the more interesting examples are those in which a flow measurement is used to diagnose a fault in an operating plant.

Case Study

Under normal operation, spent liquor from an absorption tower (figure 7) passes through the bed of a regeneration tower, is removed using a draw tray, then passed through a heater. The heated liquor is then returned to the lower half of the tower, finally exiting as the tower bottoms. However, the abnormally low temperature of the regenerated liquor suggested that some might be bypassing the heater. Normally, the flow rate of liquor through the heater should be equal to that of the bottom stream of the tower. These two flows, were checked by pulse velocity measurements using the equipment layout shown in figure 7. Measurements showed:

- There was no movement of tracer between detectors D1 and D2. This showed that there was zero flow through the heater and suggested that the draw tray was badly damaged.
- The measured velocity between detectors D3 and D4 was abnormally high and implied that the flow rate was four times greater than that indicated by an orifice plate on the inlet to the tower.

This discrepancy was so great that it was decided to re-measure the bottoms flow using the dilution technique to obtain an absolute measurement of volume flowrate. This was done by injecting radiotracer at injection point I1 and taking samples from the sample point S1. The result of this measurement was in agreement with the orifice plate meter. The only explanation was that the cross sectional area of the bottoms take-off line that was used in the pulse velocity calculation was much too high. This implied that the bore of the bottoms exit pipe was restricted... possibly by deposits.

On the strength of these measurements, Tracerco recommended that the regeneration column should be shut down as soon as possible so that the mechanical condition of the draw tray could be checked and the bottoms take-off line assessed for deposits. When these inspections were carried out it was found that the draw tray had collapsed on to the lower bed and that the exit line was partially filled with ceramic debris from the packing rings.

Conclusions

The client received a double benefit from this tracer study:

The identification of a problem with the draw tray while the plant was still on line enabled maintenance effort to be directed immediately to the source of the problem, thereby reducing downtime. Additionally, the detection of the deposits in the bottoms take off initiated a thorough clean-up of the pipe work and thus forestalled potential blockages that ultimately could have led to an unscheduled plant shutdown, which would have incurred production losses of several million dollars.

Radioisotope techniques in plant investigations are a specialized field and most industrial companies do not possess the necessary equipment and specialized radioisotope engineers to perform such work themselves. However, those who wish to benefit from this technology are increasingly making use of the services offered by our experienced Tracerco Engineers.

In closing, it must be stressed again that what has been presented here represents only a small fraction of what radioisotope techniques can achieve. They should be regarded as sensitive and versatile tools that can provide an insight into working processes that cannot be achieved by other methods. In reality, the scope of application is vast and limited only by the imagination of the user.
rose countercurrent to the catalyst flow.

A couple of days later, adjustments had been made to the steam flows. The FCC was operating much better. Initially, stationary monitoring was performed at the top of the Standpipe, 7 feet above nozzle 1. Figure 4 shows that the density was reasonably high and very consistent. Secondly, stationary monitoring was performed at nozzle 1. The density was virtually the same as above and was very consistent. Thirdly, stationary monitoring was performed at nozzle 2. The results showed that the density was much lower (higher radiation readings) and the density was reasonably consistent.

Finally, a TRACERCO Diagnostics™ - Scan was performed. The results seen in figure 5 showed that the density was relatively high at and above nozzle 1, but just below the nozzle, the density dropped rapidly and then achieved a reasonably consistent value. The steam injection rate was now properly adjusted to match the regenerated catalyst flow rate, providing good aeration without the formation of bubbles rising countercurrent to the catalyst flow.

**Conclusion**

The use of gamma radiation technology provided the customer with a clear understanding of the cause of their unstable flow. This information allowed the customer to better understand the steps needed to correct the problem.

Figure 5 – Scan results showed that the density was relatively high at and above nozzle 1, but just below the nozzle, the density dropped rapidly and then achieved a reasonably consistent value.

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**Industrial Technology Specialist Celebrates 50 Years**

Tracerco, part of Johnson Matthey Plc, is celebrating having reached its 50th anniversary as a leading industrial technology specialist serving the world’s Oil and Gas, Petrochemical and Refining industries.

From its humble beginnings in 1958, Tracerco has continued to expand its product range and geographical reach, responding to customers’ needs and market opportunities. Today, Tracerco is part of the Process Technologies Division of Johnson Matthey and is a world leader in its field. Its innovative range of specialist measurement products and services are invaluable to ensure full optimization and efficiency of its customer’s process plants. Tracerco’s success over the past 50 years can be attributed not only to its science and technological pedigree, but also to the intimacy it has with its customers.

The business now employs over 250 staff throughout the world in 25 operational bases and offices strategically located close to major oil and gas producing regions.

Andy Hurst, Managing Director commented, “Over the last fifty years there have been significant changes throughout the Oil and Gas, Petrochemical and Refining industries. Each and every project presents its unique challenges and over the years Tracerco has developed the ability to build relationships with its customers, allowing the best solution to be co-developed. Strong customer relationships, innovative R&D, establishment of local service centers and the delivery of high quality products and services has underpinned Tracerco’s continued growth and success over the past half a century. It is a great achievement to reach such a milestone anniversary. We look forward with great anticipation and enthusiasm to 50 more years of continued growth and success”.

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Simple Diagnostic Tools to Help Solve Some of Your Startup or Operating Problems

By Lowell Pless – Business Development Manager – Scanning, Pasadena, Texas USA

We have highlighted before the importance and problems with level measurement devices (see Tracerco News Vol1Ed4, Vol2Ed2). In an industry survey problems with the tower base and the reboiler return was the number 2 cause of tower malfunctions. Of all these malfunctions the measurement of the base liquid level was half of all the problems.

While restarting your operations or even during continuing operations don’t overlook the measurement of liquid levels. Tracerco can apply neutron backscatter or conventional gamma scanning to rapidly measure any liquid level that may be questionable. Please contact a technical advisor in your area to learn how Tracerco can help solve some of your startup or operating problems.

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Tracerco offers a range of non-intrusive specialist measurement instruments to ensure reliable control of your production process from separators to storage vessels. The TRACERCO™ Level Gauge shown above offers “real time in vessel” measurements with no moving parts to eliminate mechanical failure or fouling.
Please send me additional information on Tracerco's Specialist Measurement Instruments:

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