Tracerco News

Volume 3 Edition 2

Delivering Precision Diagnostics Worldwide.

Capture Real-Time Data Using Radioisotope and Chemical Tracer Technology

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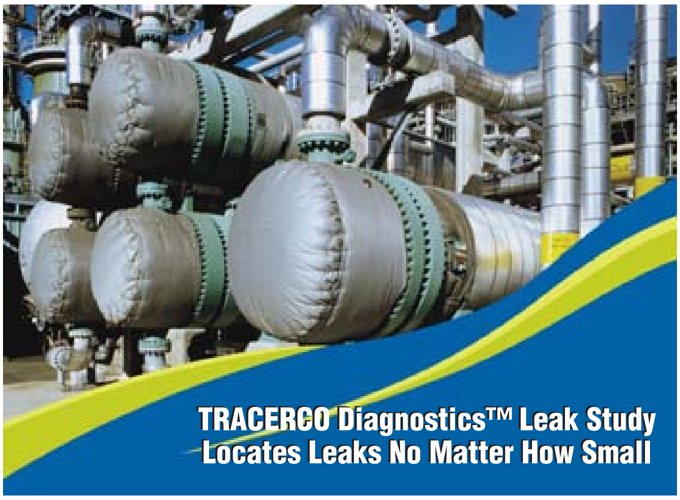

On a regular basis customers see evidence suggesting the presence of a leak; such as a drop in process efficiency or the presence of a contaminant in product. This raises the question of where in the plant the leak is occurring or is the off-spec material due to some other problem. This can be resolved using a TRACERCO Diagnostics™ Leak Study. This technology introduces a tracer material into the process, and measures where and how the material flows providing "Real-Time" data while the unit is online. The radiotracer and external leak detection technique for heat exchangers is the simplest way to perform an on-line leak test, but it is only dependable to find leaks 0.5% or more. Sometimes, the sensitivity can be improved to 0.1 – 0.2%, but the size and compactness of the system influences the sensitivity of the test.

The radiotracer and sampling technique involves the collection of samples that are "counted" sequentially with an extremely sensitive radiation detector over several minutes. Compared to the external detection technique where the tracer material flows past the detector in a few seconds, much smaller amounts of radiotracer can be measured from samples through the accumulation of counts over time. This technique has been used to find leaks as low as 0.01%, but in general is dependable to one order of magnitude lower than the external detection method (i.e., 0.05%).

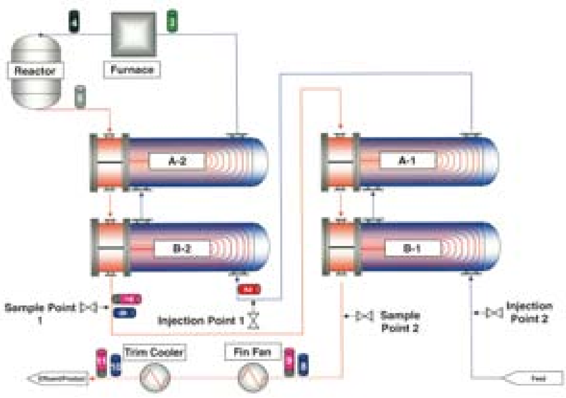

Figure 1 – *Injection, Sampling and Detector Placement*

In a number of instances customers believe that their particular leak is much smaller than 0.05%. To address the need to find leaks on a smaller scale than 0.05%, Tracerco carried out an extensive research and development programme to develop and apply specialised chemical tracers. A number of tracers have been identified and tested, some of which are compatible with organic liquid or vapour streams and others with aqueous materials. The specialised chemical tracer chosen for a particular application is chemically and thermally stable, relatively inert and can be readily detected in samples by gas chromatography coupled with mass spectrometry. Samples from leak tests are delivered to Tracerco Laboratory where they are analysed for tracer content. Though results from chemical testing are not yet available immediately on-site following the test, chemical tracers can be detected in material samples at concentrations as low as 1 part per billion (ppb) and leak percentages as low as 0.0001% are readily achievable with results available within 24 hours.

The following case study demonstrates how the combined use of radio and chemical tracers can detect the presence of a heat exchanger leak when the customer is uncertain of leak size that may be very small.

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Case Study

(Continued from page 1)

Case Study: Detection of a Suspected Heat Exchanger Leak Using Parallel Tracer Technologies

A large refinery requested a study on a set of four reactor feed/effluent heat exchangers where a leak was suspected. The customer had been experiencing high sulfur content in their effluent/product stream indicating a potential leak from the high sulfur feed into the low sulfur product. The unit engineer also believed the suspected leak rate to be ≈0.2% of the flow rate, just below the dependable detection limit of the radiotracer and external leak detection method. The customer requested Tracerco perform a TRACERCO Diagnostics™ Leak Study of the exchangers to determine the source of the problem. Due to the potential leak size and the urgency of the matter, it was decided to perform the leak test utilising three different methodologies with different levels of detection sensitivity. The three methods agreed upon were radiotracer injection with external detection, radiotracer injection with effluent sampling and chemical tracer injection with laboratory analysis.

Tracerco injected two tracers into each exchanger bank's high-pressure shell side feed inlet. A radiotracer and a suitable chemical tracer were simultaneously injected into the system. Leak detectors were strategically placed to determine the presence of the radiotracer due to a leak. Immediately following each injection, samples were taken from the lower pressure effluent outlet of each bank in a sequential manner at set time intervals. This method was conducted in an attempt to capture small amounts of tracer material due to a leak that the external detection method would have the potential to miss due to its size.

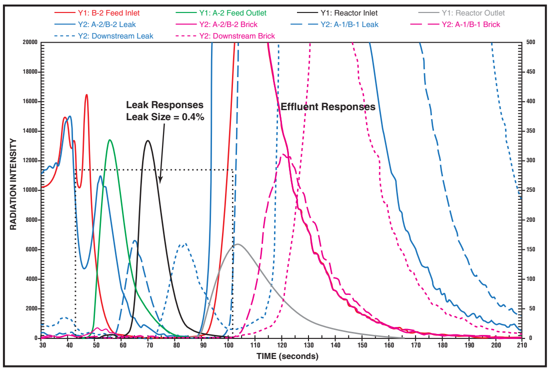

Figure 2 – *The immediate results from the external detection technique estimated the leak size to be 0.4%.*

In order to isolate any leak to a single or bank of heat exchangers, detectors can be placed in various locations depending on available piping. If present, separate injection and/or sampling locations can also be utilized to isolate the tracer and leak point to a specific exchanger. Figure 1 is an illustration of the injection, sampling and detector placement locations for this project.

Detection Technique Results

Following the initial tracer injection into Injection Point 1, a leak was observed originating from the A-2 and B-2 heat exchanger bank. The immediate results from the external detection technique estimated the leak size to be 0.4% as shown in Figure 2.

Radiation counting of the samples collected on-site also indicated a leak response illustrated in Figure 3.

The chemical tracer analysis further validated the presence of a leak by identifying the presence of the chemical tracer as both a leak and effluent response. The minimum calculated leak based on this laboratory analysis was measured at 0.2%. The results from this analysis can be seen in Figure 4.

An additional benefit of the TRACERCO Diagnostics™ Leak Study is that with one injection, the Tracerco crew can also supply our client with residence times for exchanger banks, heaters and reactors by placing additional detectors throughout the system. Effluent responses were observed in the samples collected during the leak test and were consistent in timing with that observed from the external detection.

The subsequent injection into Injection Point 2 using the same radioisotope tracer and a different chemical tracer further validated the leak in A-2 and B-2 and confirmed no detectable leak in the A-1/B-1 heat exchanger pair.

Conclusion

In this project, tracer technology confirmed the presence of a leak in two exchangers. As the leak size was relatively high, all three tracer techniques provided confidence to take corrective action to alleviate the leak problem. By conducting the different techniques simultaneously, the full leak detection size range was covered allowing detection of the leak to as low as 0.0001%. Not only was the leak narrowed to a specific heat exchanger bank, but a minimum amount of time was needed to diagnose its presence without the need for a unit shutdown. It was estimated that the application of the technology saved the plant a significant amount of maintenance costs by narrowing the leak to a specific bank, not to mention the minimization of production down time. If you would like to learn more about our heat exchanger tracer services please contact a technical advisor in your area to schedule an on-site meeting or lunch and learn presentation.

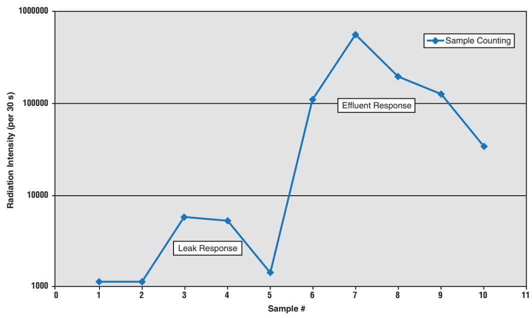

Figure 3 – *Leak Response On-site Samples Collected*

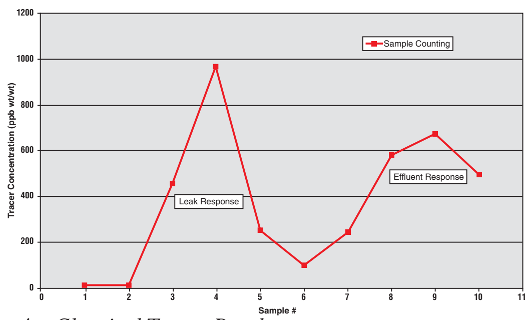

Figure 4 – *Chemical Tracer Results*

Distribution Studies Assist in Identifying Operational Performance Problems in Reactor/Separator Vessels

The residence time and distribution through a blending, reaction or separation vessel is critical to industrial process efficiencies. The distribution of liquid or gas through packed beds in these vessels can be investigated using the TRACERCO Diagnostics™ Scan technique, TRACERCO Diagnostics™ Distribution Study, TRACERCO Diagnostics™ Residence Study or all three services in combination.

A liquid or vapour distribution study using a radiotracer is performed by positioning a number of low voltage detectors around a vessel at key locations. A suitable radiotracer material is injected into the vessel that will follow the phase under investigation and the response of each detector is measured. The response will be proportional to the fraction of the total tracer that passes through that part of the vessel. Analysis of each detector response allows flow dynamics to be determined including cross sectional distribution, velocity, and residence time.

A TRACERCO Diagnostics™ Residence Time Study is performed when a radiotracer material is injected upstream of a vessel and its inlet and exit times measured using an external detector or sampling method. This information is used to determine the Mean Residence Time (MRT) through the vessel and the degree of mixing in the vessel in terms of Stirred Tank Equivalents (STE) or Inverse Peclet Number (IPN).

The data may then be used to determine design modifications or changes to process conditions necessary to eliminate problems the vessel may be experiencing and enhance conversion efficiency. In any tracer study it is imperative that the correct radiotracer be compatible with the chemicals in the process.

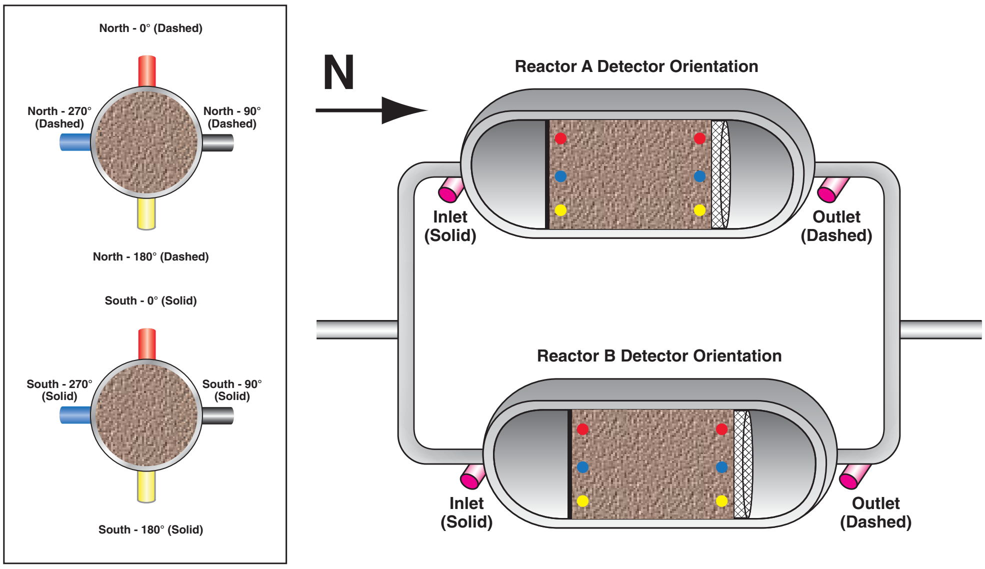

Figure 5 – *Detector placement for Reactor/Separators A & B.*

In all tracer projects Tracerco uses over 50 years of applications experience to ensure the selected radiotracer fully matches the project design and the process system under investigation.

Horizontal Reactor/Separator Case Study - MRT Results Over 6 Year Time Span Identifies Operational Problems

A series of TRACERCO Diagnostics™ Residence and Distribution Studies were conducted over a span of 6 years to assist a customer in determining the cause of problematic operations in two parallel Reactor/Separator vessels. Reactors A and B were tested by injecting an organic radioisotope tracer into the inlet nozzle and placing detectors at the inlet and outlet locations on the reactors. Additional detectors were placed in a ring of four at the North and South ends of the random packed beds in each reactor to evaluate the quality of distribution at the

Continued on page 4

Figure 6 Reactor – A

South Detector Location	Area	North Detector Location	Area
South-0º	19.6%	North-0º	19.7%
South-90º	27.4%	North-90º	27.0%
South-180º	31.3%	North-180º	26.2%
South-270º	21.7%	North-270º	27.1%

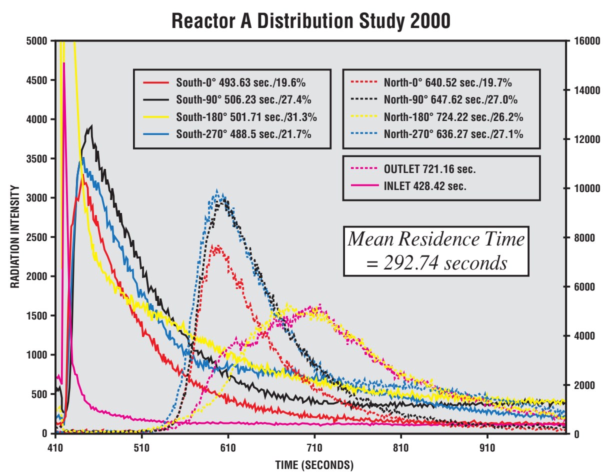

Figure 6 – *Test results for Reactor A study performed in 2000 indicated a significantly slower flow in the bottom portion of the reactor. Maldistribution was suspected to be due to fouling or damage to the bed.*

Reactor/Separator

(Continued from page 3)

entrance and exit points. (Figure 5) Each of the 4 detectors within a ring should have equal area response if good distribution is present.

Figure 6 summarises the area reponses calculated for the test of Reactor A in 2000. At the South end (inlet) of the reactor, only 19% of the tracer flowed near the top of the reactor, but 31% flowed along the bottom. In the data plot, a sharp pulse of tracer quickly reached the South-180° detector, but then a significant portion moved slowly past the detector. The responses of the other three detectors in the South ring were almost identical to each other. The North ring of detectors indicated a significantly slower flow in the bottom portion of the reactor, as evidenced by the very late response of the North-180° detector. It was suspected that this mal-distribution was due to fouling or damage to the bed.

Figure 7 summarizes the area percentages calculated for the first year analysis in Reactor B. The table of data for this reactor showed a similar distribution at the inlet (South) end, but the distribution at the North (outlet) end was high along the top of the reactor. In the data plot, the South-180° detector was shown to be the last of the ring to respond, while the North-180° detector was the first of that ring to respond. The South-180° detector had the shortest response, but had a much longer tail compared to the other three detectors in the South ring. The North-180° and North-0° detectors had much larger responses than the other two side detectors in the North ring. These differences in timing and response size indicated significant mal-distribution caused by channeling or fouling.

Figure 7 Reactor – B

South Detector Location	Area	North Detector Location	Area
South-0º	16.3%	North-0º	29.3%
South-90º	24.7%	North-90º	21.4%
South-180º	31.0%	North-180º	26.1%
South-270º	28.0%	North-270º	23.2%

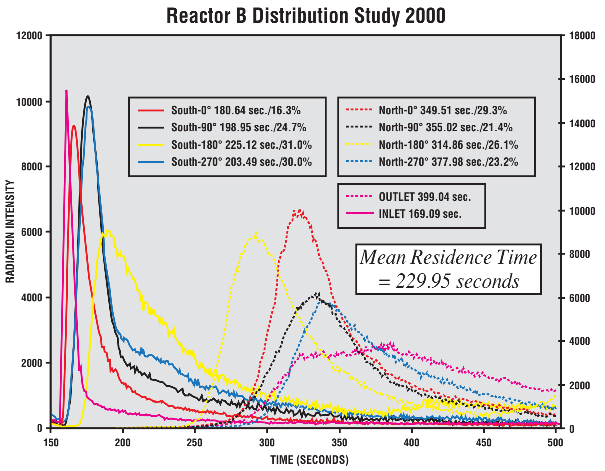

Figure 7 – *Test results for the Reactor B study performed in 2000 indicated significant maldistribution caused by channeling or fouling.*

Due to the results generated, the facility decided to carry out a shutdown and found the North screen holding the packed bed in place in Reactor B had failed. This allowed the process liquids to flow over the collapsed bed, reducing the reaction and separation efficiency. The bed in Reactor A was found to be fouled along the bottom of the vessel in the latter half of the bed.

A TRACERCO Diagnostics™ Residence Study was repeated in the same year and an additional three times over the next six years. Figure 8 summarises the Mean Residence Time calculated for each year of the study using the "Method of Moments" analysis technique.

The second residence time study for Reactor A performed in 2002 indicated there was a 40 second decrease in residence time, while the residence time for Reactor B was 205 seconds longer. A double peak observed on Figure 6 at the outlet detector (pink dashed line) in 2000 was not evident during the 2002 tests. The plant took an outage and found Reactor B was fouled, pushing more process through Reactor A.

Tests performed in 2003 indicated a very short residence time in Reactor A and an extremely long residence time through Reactor B. The double peak was in evidence again, showing tracer following two paths through the bed. Fouling in Reactor B was found when it was opened. The packed bed had been cleaned in 2002 instead of being replaced leading to a shorter life time.

The final residence time tests were performed in 2006 indicating a slight increase in mean residence time for Reactor B when compared to Reactor A. However, the beds had been in service for three years and a better process for cleaning the packing had been used during the previous shutdown resulting in better long term performance.

Conclusion

The series of residence time and distribution tests were able to alert the customer to heavy by-product sludge build-up in the beds reducing residence time and in turn the efficiency of the reactors. The tests also allowed the customer to test a variety of packed bed cleaning methods resulting in longer run times between clean outs.

TRACERCO Diagnostics™ Residence and Distribution Studies can be used to accurately diagnose integrity problems with internals and to determine the uniformity of distribution while on-line. These results can aid site personnel to identify problematic operations and make modifications to increase efficiency.

Please call us at any time to learn more about this technology and how it may enhance your process efficiencies.

Figure 8 Mean Residence Times

Year	Reactor – A Mean Residence Time Seconds	Reactor – A Mean Residence Time Minutes	Reactor – B Mean Residence Time Seconds	Reactor – B Mean Residence Time Minutes
2000	293	4.9	229	3.8
2002	253	4.2	435	7.3
2003	185	3.1	1017	17.0
2006	277	4.6	311	5.2

Figure 8 – *Mean residence times calculated for each year using the "Method of Moments" analysis technique.*

Optimise FCCU Riser Mixing through use of Non-Intrusive Radioisotope Measurement Technologies

TRACERCO Diagnostics™ Scan of the Reactor Riser

- TRACERCO Diagnostics™ Scan results can identify the size of the expansion zone providing details on unit efficiency

TRACERCO Diagnostics™ ThruVision Scan

- Study the affect of steam injection on fluidisation
- Determine the uniformity of distribution between the catalyst and feed
- Identify flow inefficiencies such as catalyst mal-distribution
- Determine if a nozzle is plugged or fouled

Hydrocarbon "cracking" within an FCCU takes place in a vertical pipe, or riser. Heavy oils are injected into a stream of hot regenerated catalyst at the base of the riser with steam, the materials mix and hydrocarbon cracking occurs. Hydrocarbon feed injector technology has made many advances over time from a centrally mounted pipe in the past to present day complex spray nozzles that are typically positioned around the riser. Control of the hydrocarbon "cracking" process in the riser is of vital importance to maximise production and minimise by-product formation. Thorough mixing of the feed and fluidised catalyst is a critical step in controlling the cracking process. The design of lifting steam and feed nozzles must be correct to achieve optimal performance. At times, injection systems do not generate an ideal homogenous mixture of fluidised catalyst particles and hydrocarbon vapour. This article describes several non-intrusive radioisotope technologies developed by Tracerco to meet customer critical measurement needs that are able to diagnose riser problems or optimise process design and conditions to maximise product throughput.

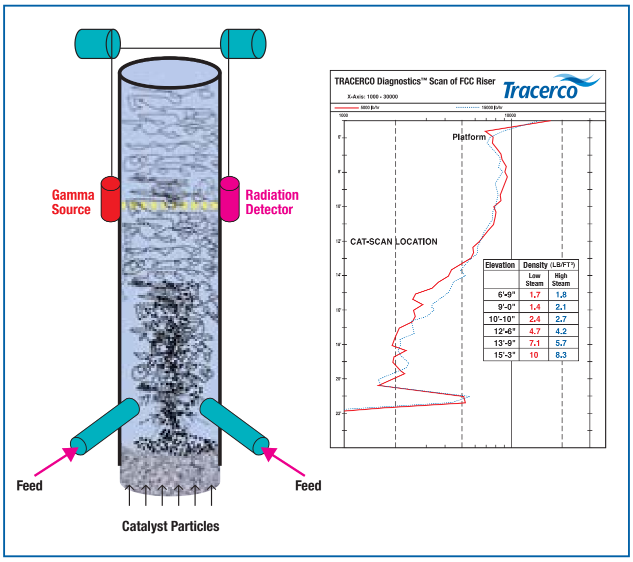

Figure 9 – *A Riser TRACERCO Diagnostics™ Scan provides the catalyst density profile down the height of the riser. Results shown above illustrate the density profiles at high and low steam rates.*

TRACERCO Diagnostics™ Scan Riser Study

A TRACERCO Diagnostics™ Scan of the riser can be used to evaluate the performance of the injection system. Results from a Riser Scan provides a catalyst density profile throughout the length of the Riser. The results provide information on the length of the expansion zone where hydrocarbon mixes with the catalyst and cracks. (Figure 9)

TRACERCO Diagnostics™ ThruVision Study

Poor fluidisation or poor mixing of the catalyst and hydrocarbon cause localised variances in the oil-to-catalyst ratio and cracking reactions. Over-cracked portions of the feed generate low-value light components, whilst at the same time the under-cracked portion produces more heavy residues. While a TRACERCO Diagnostics™ Scan provides a vertical density profile down the length of the Riser, a TRACERCO Diagnostics™ ThruVision Scan study is performed at a fixed elevation or Riser cross-section to generate a detailed cross-sectional density profile of the Riser showing flow distribution. Several measurements at selected vertical positions allows not only flow distribution to be measured but also changes to this as materials move upwards through the riser.

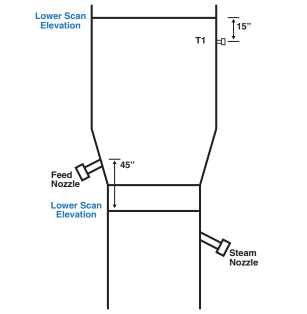

Figure 10 – *TRACERCO Diagnostics™ ThruVision Scan Orientation*

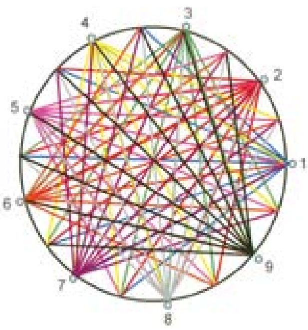

Figure 11 – *Each scan used multiple scan chords at the same elevation.*

Riser Case Study

A US Refiner requested Riser ThruVision Scans be performed for comparison of scans carried out 2 years previously to determine ongoing operational performance. Figure 10 is a representation of the two TRACERCO Diagnostics™ ThruVision Scan elevations on the Reactor Riser. Each scan was segmented into multiple scan chords at the same elevation as illustrated in Figure 11.

The first set of results illustrates density comparisons of scans performed below the

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Riser Mixing

(Continued from page 5)

feed and above the steam nozzles. The 2007 scans (Figure 12) indicated a dense core in the center of the riser and two low density areas in the Northeast and Southwest quadrants. The recent scans (Figure 12A) illustrated that the dense core in the middle had shifted slightly to the Northwest and the two low density areas in the Northeast and Southwest quadrants were not as large as indicated on the 2007 scans.

The second scan elevation results above the feed are illustrated in Figures 13 and 13A. Results of the scan performed in 2007 showed the density to be very symmetrical with four very low density areas, a dense core in the middle, and concentric rings of increasing density along the walls. The density ranged from 1 to above 20 lbs/ft^3 along the walls, with the majority of the flow between the 3 to 6 lbs/ft^3 density range.

TRACERCO Diagnostics™ ThruVision Scan results from 2009 indicated that the feed distribution had significantly improved from 2007 showing a more consistent density pattern with the lowest density between 3 to 6 lbs/ft^3 along the East Northeast wall of the riser. The central core density had increased from 6+ to 9+ lbs/ft^3 and the majority of the area was now between 6 to 9 lbs/ft^3. The concentric rings of higher density that were present in 2007 scan results disappeared, with the highest densities now on the South and West walls.

Conclusion

Density profiles obtained from scans of the Reactor Riser can be useful to determine the uniformity of distribution between catalyst and feed, and to identify flow inefficiencies such as catalyst maldistribution. TRACERCO Diagnostics™ FCCU Studies have diagnosed operating problems and helped improve the performance of all major components of FCC units.

Each project is customised to provide information needed to optimise or troubleshoot a specific process. Tracerco's FCC experts can provide on-site technical seminars discussing process optimisation and troubleshooting techniques illustrated with case studies. Contact a technical advisor in your region to learn more about our FCCU applications.

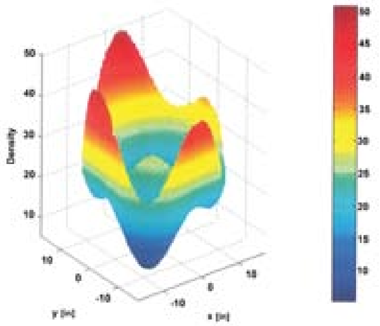

Figure 12 – *2007 TRACERCO Diagnostics™ ThruVision Scan results indicated a dense core in the center of the riser and two low density areas in the NE and SW quadrants.*

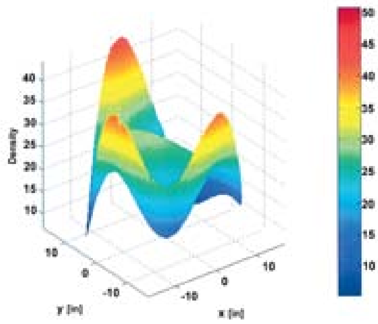

Figure 12A – *Recent scans illustrated that the dense core had shifted slightly to the NW and the two low density areas were not as large as indicated in 2007.*

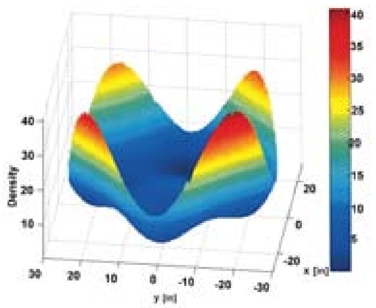

Figure 13 – *Results from 2007 scan above the feed showed the density to be symmetrical with four very low density areas.*

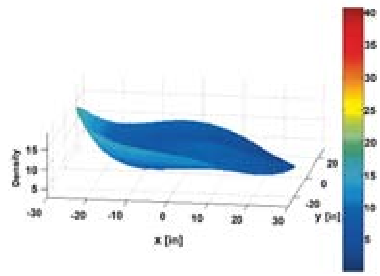

Figure 13A – *2009 TRACERCO Diagnostics™ ThruVision Scan results indicated that the feed distribution had significantly improved from 2007 showing a more consistent density pattern.*

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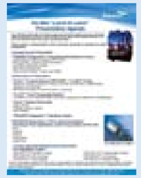
If you would like to schedule an on-site presentation, please send in the attached card or contact a representative in your area.



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