Question 87: What has been your experience with gas and/or catalyst bypassing behind monolithic refractory linings? What are the possible approaches to prevent or correct this issue?

SINGH (Indian Oil Corporation Limited)

Most refractory problems are often due to poor installation and cyclic service. Hot spots are observed in the shell due to major refractory failure; but much more commonly, from the circulation behind the refractory. We have experienced gas and catalyst going behind the monolithic refractory lining. In such cases, hot gases are driven through the refractory by the head of the catalyst just above the entry point. The gas then exits from the dilute phase at the lower pressure zone. As the gas continues to travel through cracks and heats up the metal, the metal tries to expand while the refractory does not expand, which leads to refractory failure.

Detection of localized refractory failures is done by thermography or visual inspection. Unit operation is commonly sustained by providing external cooling to the affected area, either by the low-pressure stream or air, depending on the case. And if the shell temperature cannot be maintained within the designed temperature, then we have to go for emergency shutdown and do the repairs.

The refractory failures can be minimized by proper refractory selection, anchorage, layout, and inspection after the dryout. We have changed external hot-wall risers to cold-wall risers in a couple of our units. The cold-wall systems can be monitored using thermography, which avoids surprises. As per our experience, in comparison to hot-wall design, the cold-wall riser in the orifice chamber does not require frequent refractory repairs. All of the monolithic refractory jobs are done under direct supervision of refractory experts.

As a standard practice for refractory repair, a fresh application of refractory is not done over partially fallen refractory. For repairs, the refractor must be removed up to the shell to expose the anchors before applying the refractory. In the case of refractory repair, if the repaired area is more than five square meters, then we will conduct refractory dryout by strictly following the specified procedure.

FOSHEE [Shell Global Solutions (U.S.)]

I will say that at Shell, we have definitely noticed bypassing behind monolithic refractories, especially in areas with extreme geometries such as in a Y-piece or a J-bend. Shell’s approach has been to use what is called a vapor stop. It is a ring of steel that basically protrudes into the refractory a certain distance and stops the bypassing.

SANJIV SINGH [Indian Oil Corp Ltd. (IOCL)]

Common failures of refractory linings are due to fracture, spalling, erosion, shear, separation from the shell, or increased thermal conduction. Most problems are often due to poor installation and/or cyclic service. Hot spots are observed in the shell due to major refractory failure or, much more commonly, hot flue gas circulation behind the refractory. We have experienced gas/catalyst bypassing behind monolithic refractory linings. In such cases, hot gases are driven through the refractory by the head of catalyst bed above the entry point. The gas then exits into the dilute phase/lower pressure zone. As the gas continues to travel through cracks and heat up the metal, the metal tries to grow or expand in an outward direction and attempts to pull the refractory lining with it. The refractory, on the other hand, will be resistant to any movement; hence, the nature of any cracks and gaps alters and change as the metal temperature changes. This fluctuation allows new gaps in the refractory to form and/or existing gaps to alter and is often viewed as a shift or movement in the hot spot location. In such situations, we normally try to maintain the shell temperature with air/steam injection until an opportunity to repair the affected area is available. If the shell temperatures cannot be maintained below design temperatures, then we shut down as soon as possible and make a repair.

Refractory failures can be minimized by proper refractory selection, anchorage layout, installation, and inspection after dryout. In addition, avoiding frequent and severe thermal shocks (startup and shutdown) also minimizes potential of failure.

We have changed external hot wall risers to cold wall risers in couple of our units. The cold wall system can be constantly monitored using thermography. This avoids surprises. As per our experience, in comparison to hot wall design, the cold walled riser and orifice chamber do not require frequent refractory repairs. All the monolithic refractory jobs are done under direct supervision of a refractory expert. As a standard practice for refractory repair, fresh application of refractory over partially fallen refractory is not done. For refractory repair, refractory removal up to the shell to expose the anchor is ensured before applying the refractory.

In the case of a refractory repair, if the repaired area is more than 5 m2, dryout is carried out prior to putting the refractory in service. For dryout, the recommended cycle is strictly followed. A typical dryout cycle includes heating to 110°C (230°F) to 120°C (248°F); holding for eight hours, depending on refractory thickness; and then, heating up to 350°C (662°F). For holding at 110°C (230°F), we find that MAB air is sufficiently hot enough to maintain the temperature.

To strengthen the monolithic refractory, we normally add stainless steel 304H fiber (3% by weight) in the dry stage and apply it by gunniting.

Year

2015